TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Nolichucky River Watershed (HUC 06010108)

Cocke, Greene, Hamblen, Hawkins, Unicoi, and Washington

Counties, Tennessee

FINAL

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TDEC

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. coli in Nolichucky River Watershed (HUC 06010108)

Impaired Waterbody Information

State: Tennessee
Counties: Cocke, Greene, Hamblen, and Washington
Watershed: Nolichucky (HUC 06010108)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010108001 – 0100	FLAT CREEK	4.9
TN06010108001 – 1000	NOLICHUCKY RIVER	4.0
TN06010108001 – 2000	NOLICHUCKY RIVER	7.7
TN06010108005 – 2000	NOLICHUCKY RIVER	6.6
TN06010108007 – 1000	MEADOW CREEK	23.4
TN06010108030 – 0200	JOCKEY CREEK	8.0
TN06010108030 – 0220	CARSON CREEK	17.9
TN06010108030 – 0430	MUDDY FORK	23.8
TN06010108030 – 1000	BIG LIMESTONE CREEK	3.1
TN06010108030 – 2000	BIG LIMESTONE CREEK	8.8
TN06010108033 – 1000	PIGEON CREEK	8.8
TN06010108035 – 0200	POTTER CREEK	15.3
TN06010108035 – 0900	PUNCHEON CAMP CREEK	11.5
TN06010108035 – 1000	LICK CREEK	3.9
TN06010108035 – 1800	PYBORN CREEK	6.4
TN06010108035 – 2000	LICK CREEK	2.3
TN06010108035 – 2800	MINK CREEK	9.1
TN06010108035 – 3000	LICK CREEK	7.4
TN06010108035 – 4000	LICK CREEK	4.9
TN06010108035 – 5000,6000,7000	LICK CREEK	36.1
TN06010108035 – 8000	LICK CREEK	7.2
TN06010108035 – 9000	LICK CREEK	7.7

Waterbody ID	Waterbody	Miles Impaired
TN06010108042 – 0600	MUD CREEK	8.2
TN06010108042 – 1000	BENT CREEK	13.7
TN06010108043 – 1000	LONG CREEK	13.5
TN06010108064 – 1000,2000	SINKING CREEK	23.4
TN06010108102 – 2000	RICHLAND CREEK	6.1
TN06010108510 – 0400	HOMINY CREEK	7.0
TN06010108510 – 1000	LITTLE LIMESTONE CREEK	8.0
TN06010108510 – 2000	LITTLE LIMESTONE CREEK	13.5

Designated Uses:

The designated use classifications for waterbodies in the Nolichucky River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sinking Creek (Mile 5.2 to origin), Lick Creek (Mile 49.0 to origin), and Nolichucky River (Mile 0.0 to 5.3 and Mile 7.7 to state line) are also designated for domestic water supply.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January, 2004* for recreation use classification (most stringent):

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

TMDL Scope:

Waterbodies identified on the Final 2006 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Nolichucky River Watershed were developed and expressed as the daily allowable load that assures compliance with the E. Coli 487 CFU/100 mL maximum water quality criteria for Tier II waterbodies and 941 CFU/100 mL maximum water quality criteria for non-Tier II waterbodies. Load reductions were also developed using a load duration curve methodology to assure compliance with the appropriate maximum water quality criteria. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the daily load expressions and subsequent percent load reductions required to meet desired maximum concentrations for E. coli. When sufficient data were available, load reductions may also be determined based on geometric mean criteria.

Critical Conditions:

Water quality data collected over a period of 10 years for load duration curve analysis were used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

The 10-year period used for LSPC model simulation period for development of load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Explicit MOS = 10% of the E. coli water quality criteria for each impaired subwatershed or drainage area.

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Nolichucky River Watershed (HUC 06010108)

HUC-12 Subwatershed (06010108__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs				LAs
					WWTFs [a]	Leaking Collection Systems [c]	CAFOs	MS4s [d]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day/acre]	[CFU/day/acre]
0206	Little Limestone Creek	TN06010108510 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	$1.920 \times 10^{10,b}$	NA	NA	$2.122 \times 10^{6} * Q – 1.968 \times 10^{6}$	$2.122 \times 10^{6} * Q – 1.968 \times 10^{6}$
	Little Limestone Creek	TN06010108510 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	$1.920 \times 10^{10,b}$	0	NA	$1.046 \times 10^{6} * Q – 9.698 \times 10^{5}$	$1.046 \times 10^{6} * Q – 9.698 \times 10^{5}$
	Hominy Branch	TN06010108510 – 0400	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$8.434 \times 10^{6} * Q$	$8.434 \times 10^{6} * Q$
0401	Muddy Fork	TN06010108030 – 0430	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$2.042 \times 10^{6} * Q$	$2.042 \times 10^{6} * Q$
0402	Big Limestone Creek	TN06010108030 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	1.781×10^{8}	NA	NA	$2.246 \times 10^{5} * Q – 3.704 \times 10^{3}$	$2.246 \times 10^{5} * Q – 3.704 \times 10^{3}$
	Big Limestone Creek	TN06010108030 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	1.781×10^{8}	NA	NA	$6.142 \times 10^{5} * Q – 5.285 \times 10^{3}$	$6.142 \times 10^{5} * Q – 5.285 \times 10^{3}$
	Carson Creek	TN06010108030 – 0220	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$3.375 \times 10^{6} * Q$	$3.375 \times 10^{6} * Q$
	Jockey Creek	TN06010108030 – 0200	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$1.859 \times 10^{6} * Q$	$1.859 \times 10^{6} * Q$
0501 (DA)	Sinking Creek	TN06010108064 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	8.548×10^{8}	NA	NA	NA	$2.186 \times 10^{6} * Q – 9.026 \times 10^{4}$
	Sinking Creek	TN06010108064 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	NA	$3.252 \times 10^{6} * Q$
0504	Richland Creek	TN06010108102 – 2000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	NA	0	NA	$1.207 \times 10^{6} * Q$	$1.207 \times 10^{6} * Q$
0505	Nolichucky River	TN06010108005 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	$2.773 \times 10^{11,b}$	NA	0	NA	$1.360 \times 10^{4} * Q – 3.493 \times 10^{5}$
	Meadow Creek	TN06010108007 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	3.318×10^{8}	NA	0	NA	$8.513 \times 10^{5} * Q – 2.615 \times 10^{4}$
	Pigeon Creek	TN06010108033 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	NA	$5.169 \times 10^{6} * Q$
0601	Nolichucky River	TN06010108001 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	$2.773 \times 10^{11,b}$	NA	0	$1.007 \times 10^{4} * Q – 2.586 \times 10^{5}$	$1.007 \times 10^{4} * Q – 2.586 \times 10^{5}$
	Nolichucky River	TN06010108001 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	$2.773 \times 10^{11,b}$	NA	0	$1.021 \times 10^{4} * Q – 2.621 \times 10^{5}$	$1.021 \times 10^{4} * Q – 2.621 \times 10^{5}$
0603	Bent Creek	TN06010108042 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	NA	NA	0	$3.645 \times 10^{5} * Q$	$3.645 \times 10^{5} * Q$
	Mud Creek	TN06010108042 – 0600	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$9.675 \times 10^{6} * Q$	$9.675 \times 10^{6} * Q$
0604	Flat Creek	TN06010108001 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$3.919 \times 10^{6} * Q$	$3.919 \times 10^{6} * Q$
0605	Long Creek	TN06010108043 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$9.509 \times 10^{5} * Q$	$9.509 \times 10^{5} * Q$

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Nolichucky River Watershed (HUC 06010108) (cont'd)

HUC-12 Subwatershed (06010108__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs				LAs
					WWTFs [a]	Leaking Collection Systems	CAFOs	MS4s [c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day/acre]	[CFU/day/acre]
0701	Lick Creek	TN06010108035 – 8000	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	0	NA	6.173×10^{5} * Q
	Lick Creek	TN06010108035 – 9000	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	2.669×10^{6} * Q
	Pyborn Creek	TN06010108035 – 1800	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	7.720×10^{6} * Q
0702	Lick Creek	TN06010108035 – 6000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.882×10^{9}	NA	0	NA	1.920×10^{5} * Q – 3.601×10^{4}
	Lick Creek	TN06010108035 – 7000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.562×10^{9}	0	NA	NA	3.332×10^{5} * Q – 5.733×10^{4}
	Puncheon Camp Creek	TN06010108035 – 0900	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	4.469×10^{6} * Q
0705	Lick Creek	TN06010108035 – 1000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.889×10^{10}	NA	NA	NA	1.251×10^{5} * Q – 2.350×10^{5}
	Lick Creek	TN06010108035 – 2000	1.20×10^{10} * Q	1.20×10^{9} * Q	3.889×10^{10}	NA	NA	NA	6.546×10^{4} * Q – 2.357×10^{5}
	Lick Creek	TN06010108035 – 3000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	NA	NA	NA	1.268×10^{5} * Q – 2.365×10^{5}
	Lick Creek	TN06010108035 – 4000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	NA	NA	NA	1.376×10^{5} * Q – 2.567×10^{5}
	Lick Creek	TN06010108035 – 5000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	0	NA	NA	1.385×10^{5} * Q – 2.583×10^{5}
	Mink Creek	TN06010108035 – 2800	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	0	NA	NA	3.400×10^{6} * Q
	Potter Creek	TN06010108035 – 0200	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	4.376×10^{6} * Q

Notes: NA = Not Applicable.
Q = Mean Instream Daily Flow (cfs)

a. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permit; at no time shall concentration be greater than the appropriate E. coli standard (487 CFU/100 mL or 941 CFU/100 mL).

b. The WLA listed is for the subwatershed and is equal to the sum of the WLAs for the individual facilities. WLAs for individual WWTFs correspond to existing E. coli permit limits at facility design flow.

c. Applies to any MS4 discharge loading in the subwatershed.

PROPOSED E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) NOLICHUCKY RIVER WATERSHED (HUC 06010108)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated uses for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for waterbodies in the Nolichucky River Watershed, identified on the Final 2006 303(d) list as not supporting designated uses due to E. coli. Portions of the Nolichucky River Watershed lie in both Tennessee and North Carolina. This document addresses only impaired waterbodies in Tennessee. TMDL analyses were performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs were developed for an impaired waterbody drainage area only.

3.0 WATERSHED DESCRIPTION

The Nolichucky River Watershed (HUC 06010108) is located in Eastern Tennessee (Figure 1), primarily in Greene, Unicoi, and Washington Counties. The Nolichucky River Watershed lies within two Level III ecoregions (Blue Ridge Mountains, Ridge and Valley) and contains eight Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **Southern Igneous Ridges and Mountains (66d)** occur in Tennessee's northeastern Blue Ridge near the North Carolina border, primarily on Precambrian-age igneous and high-grade metamorphic rocks. The typical crystalline rock types include granite, gneiss, schist, and metavolcanics, covered by well-drained, acidic brown loamy soils. Elevations of this rough, dissected region range from 2000-6200 feet, with Roan Mountain reaching 6286 feet. Although there are a few small areas of pasture and apple orchards, the region is mostly forested; Appalachian oak and northern hardwood forests predominate.

- **The Southern Sedimentary Ridges (66e)** in Tennessee include some of the westernmost foothill areas of the Blue Ridges Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald, and Iron Mountain areas. Slopes are steep, and elevations are generally 1000-4500 feet. The rocks are primarily Cambrian-age sedimentary (shale, sandstone, siltstone, quartzite, conglomerate), although some lower stream reachs occur on limestone. Soils are predominantly friable loams and fine sandy loams with variable amounts of sandstone rock fragments, and support mostly mixed oak and oak-pine forests.
- **Limestone Valleys and Coves (66f)** are small but distinct lowland areas of the Blue Ridge, with elevations mostly between 1500 and 2500 feet. About 450 million years ago, older Blue Ridge rocks to the east were forced up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Cambrian or Ordovician-age limestones, as seen especially in isolated, deep cove areas that are surrounded by steep mountains. The main areas of limestone include the Mountain City lowland area and Shady Valley in the north; and Wear Cove, Tuckaleechee Cove, and Cades Cove of the Great Smoky Mountains in the south. Hay and pasture, with some tobacco patches on small farms, are typical land uses.
- **The Southern Metasedimentary Mountains (66g)** are steep, dissected, biologically-diverse mountains that include Clingmans Dome (6643 feet), the highest point in Tennessee. The Precambrian-age metamorphic and sedimentary geologic materials are generally older and more metamorphosed than the Southern Sedimentary Ridges (66e) to the west and north. The Appalachian oak forests and, at higher elevations, the northern hardwoods forests include a variety of oaks and pines, as well as silverbell, hemlock, yellow poplar, basswood, buckeye, yellow birch, and beech. Spruce-fir forests, found generally above 5500 feet, have been affected greatly over the past twenty-five years by the balsam woolly aphid. The Copper Basin, in the southeast corner of Tennessee, was the site of copper mining and smelting from the 1850's to 1987, and once left more than fifty square miles of eroded earth.
- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.
- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture or have reverted to brush and forested land, while small fields of hay, corn , tobacco, and garden crops are grown on the foot slopes and bottomland.

- **The Southern Sandstone Ridges (67h)** ecoregion encompasses the major sandstone ridges, but these ridges also have areas of shale and siltstone. The steep, forested chemistry of streams flowing down the ridges can vary greatly depending on the geologic material. The higher elevation ridges are in the north, including Wallen Ridge, Powell Mountain, Clinch Mountain, and Bays Mountain. White Oak Mountain in the south has some sandstone on the west side, but abundant shale and limestone as well. Grindstone Mountain, capped by the Gizzard Group sandstone, is the only remnant of Pennsylvanian-age strata in the Ridge and Valley of Tennessee.

- **The Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower slopes, knobs, and draws.

The Nolichucky River Watershed, located in Cocke, Greene, Hamblen, Hawkins, Unicoi, and Washington Counties, Tennessee, has a drainage area of approximately 1,128 square miles (mi^2) in Tennessee. The entire watershed, including both Tennessee and North Carolina, drains approximately 1,744 square miles. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Nolichucky River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Tennessee portion of the Nolichucky River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Nolichucky River Watershed is forest (61.2%) followed by pasture (28.1%). Urban areas represent approximately 2.3% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Nolichucky River Watershed are presented in Appendix A.

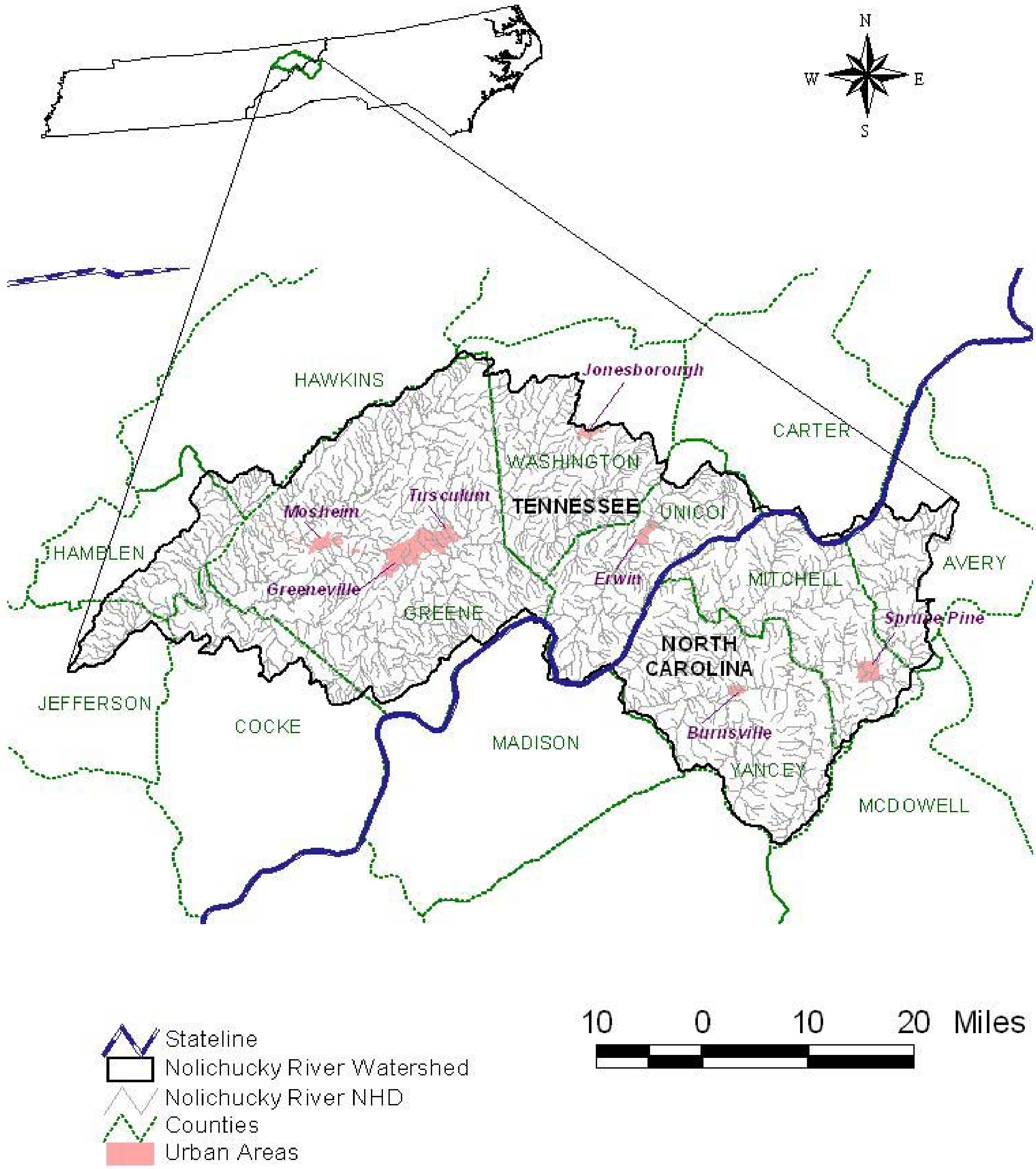

Figure 1. Location of the Nolichucky River Watershed.

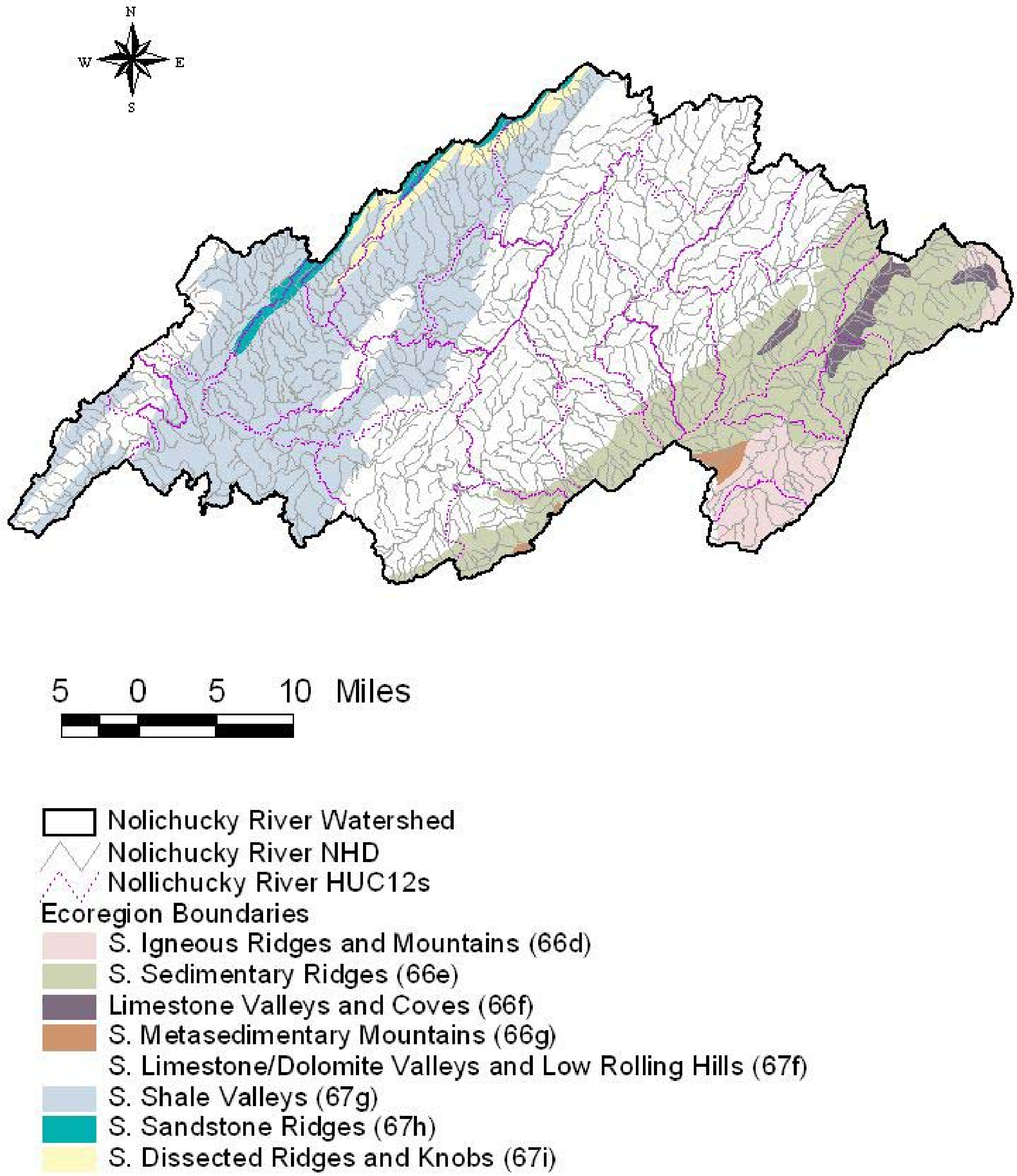

Figure 2. Level IV Ecoregions in the Nolichucky River Watershed.

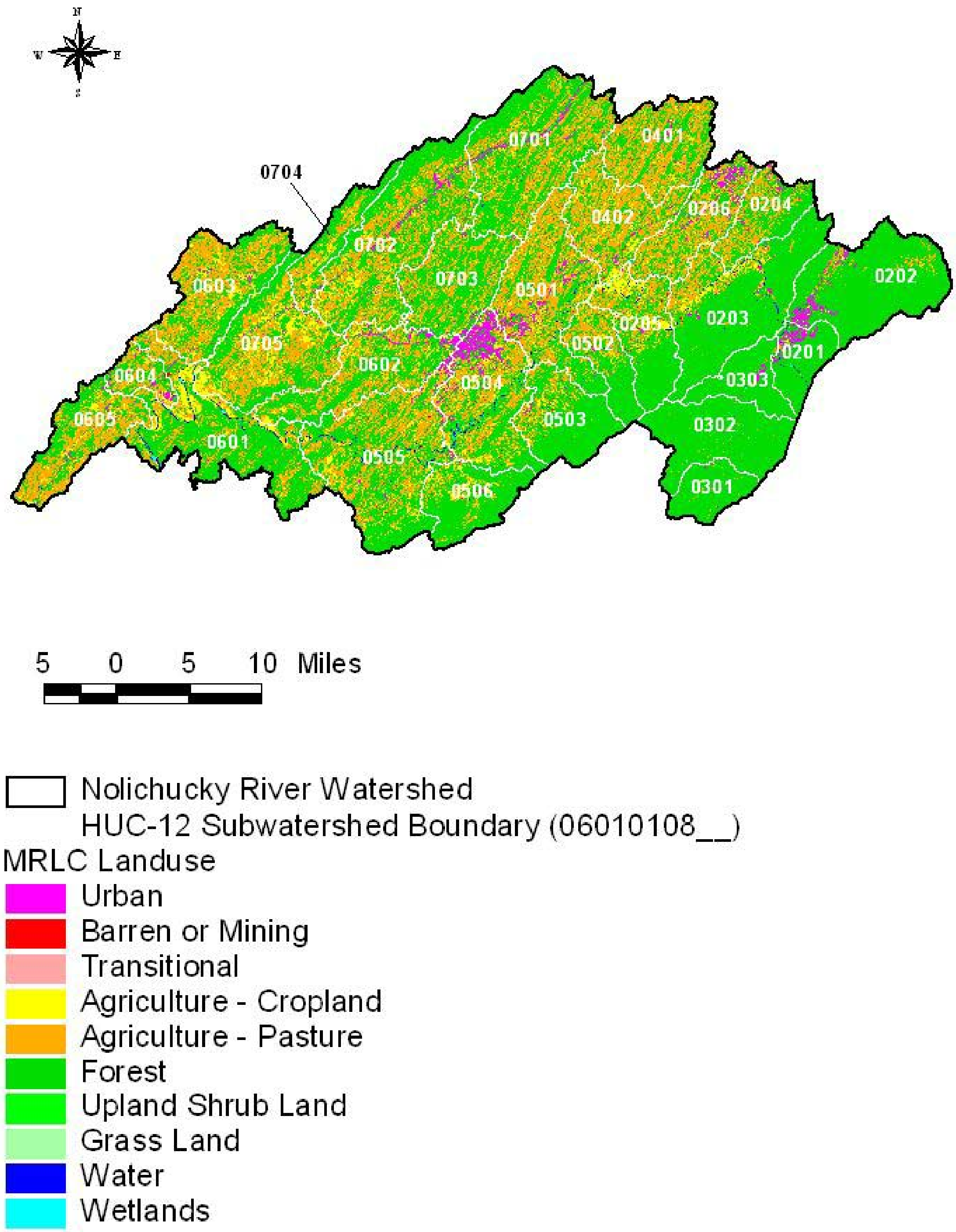

Figure 3. Land Use Characteristics of the Nolichucky River Watershed.

Table 1. MRLC Land Use Distribution – Nolichucky River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand Clay	1,974	0.3
Deciduous Forest	222,861	30.9
Emergent Herbaceous Wetlands	162	0.0
Evergreen Forest	88,332	12.2
High Intensity Commercial/Industrial/ Transportation	5,799	0.8
High Intensity Residential	869	0.1
Low Intensity Residential	10,363	1.4
Mixed Forest	131,043	18.1
Open Water	2,608	0.4
Other Grasses (Urban/recreational)	4,553	0.6
Pasture/Hay	203,168	28.1
Quarries/Strip Mines/ Gravel Pits	143	0.0
Row Crops	49,333	6.8
Transitional	39	0.0
Woody Wetlands	1,086	0.2
Total	**722,335**	**100.0**

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2006 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in October of 2006. This list identified portions of twenty waterbodies in the Nolichucky River Watershed as not supporting designated use classifications due, in part, to E. coli (see Table 2 & Figure 4). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sinking Creek (Mile 5.2 to origin), Lick Creek (Mile 49.0 to origin), and Nolichucky River (Mile 0.0 to 5.3 and Mile 7.7 to state line) are also designated for domestic water supply.

When used in the context of waterbody assessments, the term pathogens is defined as disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested or introduced into the body. The primary sources for pathogens are untreated or inadequately treated human or animal fecal matter. The E. coli and fecal coliform groups are indicators of the presence of pathogens in a stream.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the Nolichucky waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. Of the use classifications with numeric criteria for pathogens, the recreation use classification is the most stringent and will be used to establish target levels for TMDL development. The coliform water quality criteria, for protection of the recreation use classification, is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January 2004* (TDEC, 2004). Section 1200-4-3-.03 (4) (f) states:

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL.
>
> Additionally, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

A portion of Bent Creek (from junction of Warrensburg and Mountain Roads to Mud Creek) has been classified as Tier II. A portion of Sinking Creek (from Afton Road to headwaters) also has been classified as Tier II. Portions of Big Limestone Creek (within Davy Crockett Birthplace State Historic Park), Lick Creek (within the Lick Creek Bottoms Wildlife Management Area), Meadow Creek (within Cherokee National Forest), and Richland Creek (within Nolichucky Waterfowl Sanctuary) have been classified as Tier II. Portions of the Nolichucky River, including the portion from Douglas embayment to Evans Island and the portion within Cherokee National Forest, have been classified as Tier II. As of February 2, 2006, none of the other impaired waterbodies in the Nolichucky River Watershed have been classified as either Tier II or Tier III streams.

The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 487 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for impaired waterbodies classified as Tier II streams. The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

Table 2 Final 2006 303(d) List for E. coli Impaired Waterbodies – Nolichucky River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010108001 – 0100	FLAT CREEK	4.9	Escherichia coli	Pasture Grazing
TN06010108001 – 1000	NOLICHUCKY RIVER	4.0	Loss of biological integrity due to siltation Escherichia coli	Agriculture Source in Other State
TN06010108001 – 2000	NOLICHUCKY RIVER	7.7	Escherichia coli	Pasture Grazing
TN06010108005 – 2000	NOLICHUCKY RIVER	6.6	Loss of biological integrity due to siltation Escherichia coli	Agriculture Source in Other State
TN06010108007 – 1000	MEADOW CREEK	23.4	Escherichia coli	Livestock in Stream
TN06010108030 – 0200	JOCKEY CREEK	8.0	Nitrate Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing
TN06010108030 – 0220	CARSON CREEK	17.9	Nitrate Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing Livestock in Stream
TN06010108030 – 0430	MUDDY FORK	3.0	Escherichia coli	Agriculture
TN06010108030 – 1000	BIG LIMESTONE CREEK	3.1	Escherichia coli	Pasture Grazing
TN06010108030 – 2000	BIG LIMESTONE CREEK	8.8	Phosphorus Nitrate Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing
TN06010108033 – 1000	PIGEON CREEK	8.8	Escherichia coli	Pasture Grazing

Table 2 (cont'd). Final 2006 303(d) List for E. coli Impaired Waterbodies – Nolichucky River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010108035 – 0200	POTTER CREEK	15.3	Loss of biological integrity due to siltation Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing
TN06010108035 – 0900	PUNCHEON CAMP CREEK	11.5	Nutrients Loss of biological integrity due to siltation Escherichia coli	Agriculture
TN06010108035 – 1000	LICK CREEK	3.9	Nutrients Loss of biological integrity due to siltation Other habitat alterations Escherichia coli	Pasture Grazing
TN06010108035 – 1800	PYBORN CREEK	6.4	Escherichia coli	Pasture Grazing
TN06010108035 – 2000	LICK CREEK	2.3	Escherichia coli	Pasture Grazing
TN06010108035 – 2800	MINK CREEK	9.1	Escherichia coli	Pasture Grazing
TN06010108035 – 3000	LICK CREEK	7.4	Nutrients Loss of biological integrity due to siltation Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing
TN06010108035 – 4000	LICK CREEK	4.9	Escherichia coli	Pasture Grazing
TN06010108035 – 5000	LICK CREEK	17.8	Nutrients Loss of biological integrity due to siltation Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing
TN06010108035 – 6000	LICK CREEK	8.9		
TN06010108035 – 7000	LICK CREEK	9.4		

Table 2 (cont'd). Final 2006 303(d) List for E. coli Impaired Waterbodies – Nolichucky River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010108035 – 8000	LICK CREEK	7.2	Escherichia coli	Pasture Grazing
TN06010108035 – 9000	LICK CREEK	7.7	Nutrients Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing
TN06010108042 – 0600	MUD CREEK	8.2	Escherichia coli	Pasture Grazing
TN06010108042 – 1000	BENT CREEK	13.7	Escherichia coli	Pasture Grazing
TN06010108043 – 1000	LONG CREEK	13.5	Escherichia coli	Pasture Grazing
TN06010108064 – 1000	SINKING CREEK	3.8	Escherichia coli	Pasture Grazing
TN06010108064 – 2000	SINKING CREEK	19.6		
TN06010108102 – 2000	RICHLAND CREEK	6.1	Nutrients Loss of biological integrity due to siltation Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing Discharges from MS4 area
TN06010108510 – 0400	HOMINY CREEK	7.0	Nitrate Escherichia coli	Agriculture
TN06010108510 – 1000	LITTLE LIMESTONE CREEK	8.0	Nitrate Escherichia coli	Pasture Grazing
TN06010108510 – 2000	LITTLE LIMESTONE CREEK	13.5	Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Pasture Grazing

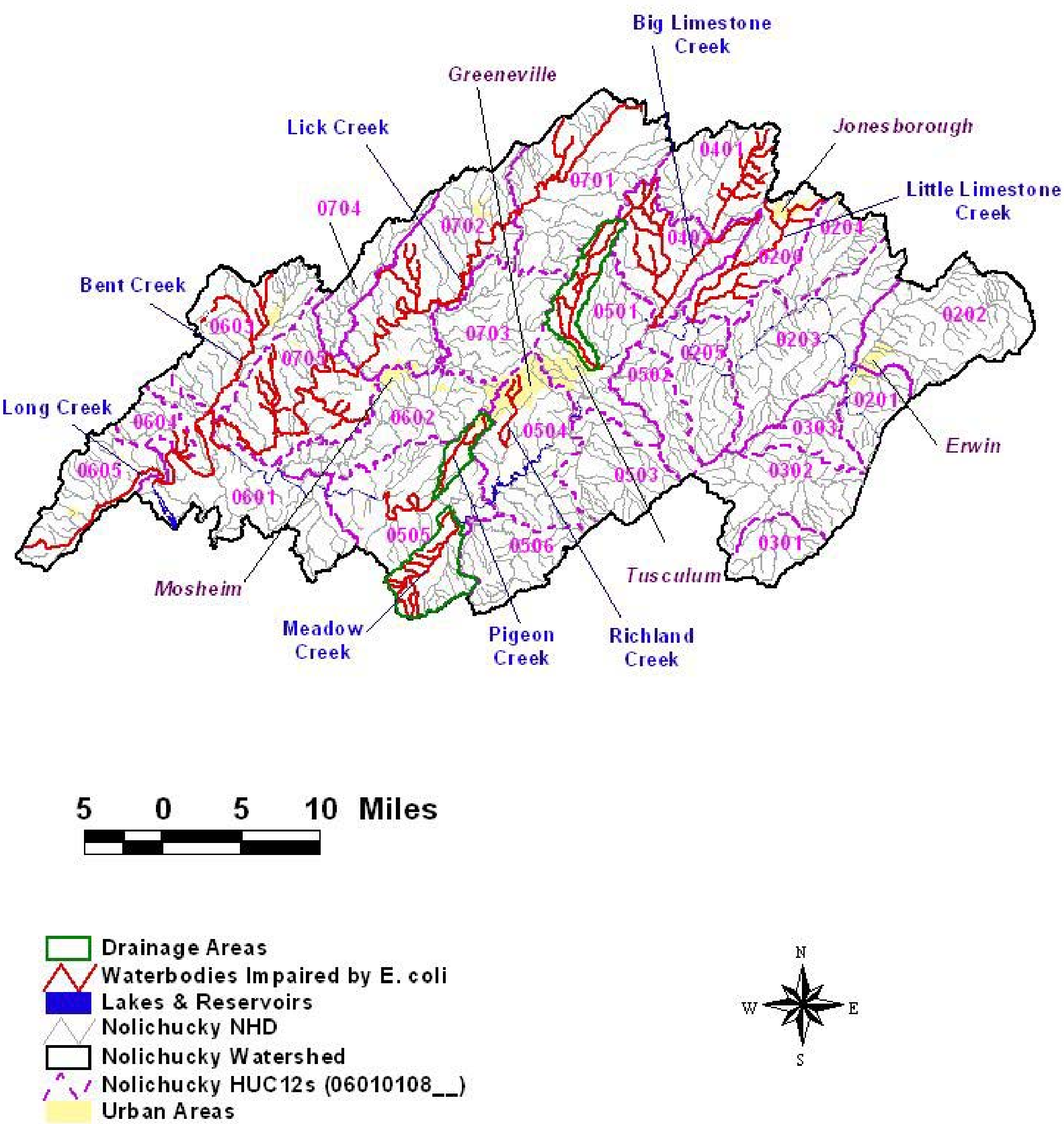

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2006 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Nolichucky River Watershed. Monitoring stations located on Tier II waterbodies have been italicized:

- HUC-12 06010108_0206:
  - HOMIN000.2WN – Hominy Branch, 150 yds u/s Gravel Hill Rd.
  - LLIME000.1WN – Little Limestone Creek, 50 yds d/s SR 353 at Broylesville
  - LLIME007.0WN – Little Limestone Creek, on New Victory Rd.
  - LLIME007.7WN – Little Limestone Creek, 50 yds d/s SR 353, near Davey Crockett High School
- HUC-12 06010108_0401:
  - MUDDY000.4WN – Muddy Fork, at Old Stage Rd.
  - MUDDY005.1WN – Muddy Fork, at Horseshoe Bend Rd.
  - MUDDY007.1WN – Muddy Fork, at Pleasant Valley Rd.
- HUC-12 06010108_0402:
  - *BLIME000.5GE – Big Limestone Creek, 100 yds u/s Keebler Rd.*
  - *BLIME002.9WN – Big Limestone Creek, at bridge, off old SR 34*
  - BLIME004.0WN – Big Limestone Creek, 100 yds d/s 11E
  - BLIME007.7WN – Big Limestone Creek, at bridge on Kyker Rd., off US Hwy 11E
  - CARSO000.1WN – Carson Creek, 100 yds u/s Clear Spring Rd.
  - CARSO001.8WN – Carson Creek, at Bowmantown Rd.
  - JOCKE000.1WN – Jockey Creek, 100 yds u/s Opie Arnold Rd.
  - JOCKE003.2GE – Jockey Creek, at Old Stage Rd.
- HUC-12 06010108_0501:
  - SINKI000.2GE – Sinking Creek, at Greenwood Rd., off Blackberry Rd.
  - SINKI000.5GE – Sinking Creek, 100 yds u/s Blackberry & Roberts Rd.
  - SINKI003.0GE – Sinking Creek, at Old Stage Rd.
  - SINKI004.5GE – Sinking Creek, on Afton Rd., 1.3 mi past intersection with Old Stage Rd., at driveway on left
- HUC-12 06010108_0504:
  - *RICHL001.3GE – Richland Creek, at Links Mill Rd.*
  - RICHL004.3GE – Richland Creek, south of Greeneville/Blue Jay Rd.
  - RICHL006.0GE – Richland Creek, u/s Old Asheville Hwy at Devils Elbow
  - RICHL007.1GE – Richland Creek, in Greeneville, at Jones Bridge Rd.

- HUC-12 06010108_0505:
    - *MEADO000.4GE – Meadow Creek, west of intersection of W. Allens Bridge and S. Allens*
    - *MEADO002.7GE – Meadow Creek, Nolichucky Rd., off Birdwill Mill Road 100*
    - *MEADO004.1GE – Meadow Creek, St. James Rd., off Cedar Creek Rd.*
    - *MEADO006.4CO – Meadow Creek, gravel drive, 0.15 mi west of Greene/Cocke line, on Long Creek Rd.*
    - NOLIC038.5GE – Nolichucky River, d/s Pigeon Creek
    - NOLIC039.3GE – Nolichucky River, d/s Pigeon Creek
    - PIGEO000.9GE – Pigeon Creek, Buffalo Rd., off Pigeon Creek Rd.
    - PIGEO001.0GE – Pigeon Creek, 100 m. u/s Buffalo Rd.
    - PIGEO002.8GE – Pigeon Creek, Gibson Rd., off Hwy 321
    - PIGEO005.7GE – Pigeon Creek, Lick Hollow Rd., off US Hwy 321
- HUC-12 06010108_0601:
    - *NOLIC005.3HA – Nolichucky River, at Hales bridge*
- HUC-12 06010108_0603:
    - *BENT007.2HA – Bent Creek, Mud Creek Rd. bridge, on Ralph Ray Rd.*
    - *ECO67G05 – Bent Creek, u/s junction of Warrensburg and Mountain Rd.*
    - MUD000.4HA – Mud Creek, at Stagecoach Rd. bridge
- HUC-12 06010108_0604:
    - FLAT000.1HA – Flat Creek, 400 yds d/s Hwy 160
    - FLAT000.6HA – Flat Creek, d/s Hwy 160 bridge
    - FLAT001.0HA – Flat Creek, 100 yds u/s Chucky River Rd.
- HUC-12 06010108_0605:
    - LONG000.7HA – Long Creek, at River Rd.
- HUC-12 06010108_0701:
    - LICK052.3GE – Lick Creek, 100 yds u/s Lost Mountain Pike
    - LICK061.0GE – Lick Creek, 100 yds u/s Campbell Rd.
    - PYBOR000.1GE – Pyborn Creek, on Barkley Rd., off Woolsey Rd., west of Jearoldstown Rd.
- HUC-12 06010108_0702:
    - LICK024.2GE – Lick Creek, 600 yds u/s Hwy 34
    - LICK033.6GE – Lick Creek, 25 yds u/s Old SR 70
    - LICK040.8GE – Lick Creek, 100 yds d/s dirt road off John Graham Rd.

- LICK045.2GE – Lick Creek, 100 yds u/s Wesley Chapel Rd.
- LICK047.2GE – Lick Creek, on Crumley Rd., off SR172
- PCAMP000.5GE – Puncheon Camp Creek, off route 70 thru field road, 50 yds u/s culvert

- HUC-12 06010108_0705:
  - LICK001.0GE – Lick Creek, on Warrensburg/SR340, at Fish Hatchery Rd., Cooper bridge
  - LICK003.8GE – Lick Creek, u/s McDonald Rd. (SR348) at Beulah, 50 yds u/s Brown Springs Rd.
  - *LICK006.5GE – Lick Creek, 100 yds u/s Smelcer Rd.*
  - *LICK011.9GE – Lick Creek, at Bible Chapel Rd.*
  - LICK0015.5GE – Lick Creek, 70 yds u/s Green Rd.
  - LICK020.5GE – Lick Creek, at Pottertown Rd.
  - MINK001.0GE – Mink Creek, u/s McDonald Rd. (SR348) at Bible Chapel, 100 yds u/s Brown Springs Rd.
  - POTTE000.3GE – Potter Creek, on Sapp Rd., off Concord Rd., west of Thula

The location of these monitoring stations is shown in Figures 5 thru 9. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU/100 mL (non-Tier II) maximum E. coli standard at many monitoring stations. Water quality monitoring results for those stations with 10% or more of samples exceeding water quality maximum criteria are summarized in Table 3.

Several of the water quality monitoring stations (Table 3 and Appendix B) have at least one E. coli sample value reported as >2419. In addition, at three of these sites, the maximum E. coli sample value is >2419. For the purpose of calculating summary data statistics, TMDLs, Waste Load Allocations (WLAs), and Load Allocations (LAs), these data values are treated as (equal to) 2419. Therefore, the calculated results are considered to be estimates. Future E. coli sample analyses at these sites should follow established protocol. See Section 9.4.

There were not enough data to calculate the geometric mean at each monitoring station. Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated.

Note that several waterbodies have been divided into multiple segments and are represented by multiple water quality monitoring stations. The three impaired segments of Nolichucky River are represented by two water quality monitoring stations. The monitoring station at mile 5.3 is located in segment 001-1000 (from the mouth to Flat Creek). There are no monitoring stations located in segment 001-2000 (from Flat Creek to Bent Creek). The monitoring station at mile 38.5/39.3 is located in segment 005-2000 (from Evans Island to Pigeon Creek).

The two impaired segments of Big Limestone Creek are represented by four water quality monitoring stations. The monitoring stations at miles 0.5 and 2.9 are located in segment 030-1000 (from the mouth to an unnamed tributary near Limestone). The monitoring stations at miles 4.0 and 7.7 are located in segment 030-2000 (from the unnamed tributary to the headwaters).

The two impaired segments of Little Limestone Creek are represented by three water quality monitoring stations. The monitoring stations at miles 0.1 and 7.0 are located in segment 510-1000 (from the mouth to Brown Creek at Telford). The monitoring station at mile 7.7 is located in segment 510-2000 (from Brown Creek to the headwaters).

The two impaired segments of Sinking Creek are represented by four water quality monitoring stations. The monitoring stations at miles 0.2, 0.5, and 3.0 are located in segment 064-1000 (from the mouth to unnamed tributary northwest of Afton). The monitoring station at mile 4.5 is located in segment 064-2000 (from the unnamed tributary to the headwaters).

The nine impaired segments of Lick Creek are represented by thirteen water quality monitoring stations. The monitoring station at mile 1.0 is located in segment 035-1000 (from the mouth to Highway 348). The monitoring station at mile 3.8 is located in segment 035-2000 (from Highway 348 to Black Creek). The monitoring stations at miles 6.5 and 11.9 are located in segment 035-3000 (from Black Creek to Skipper Creek). The monitoring station at Mile 15.5 is located in segment 035-4000 (from Skipper Creek to Mud Creek). The monitoring stations at miles 20.5 and 24.2 are located in segment 035-5000 (from Mud Creek to Highway 70). The monitoring stations at miles 33.6 and 40.8 are located in segment 035-6000 (from Highway 70 to Grassy Creek). The monitoring stations at miles 45.2 and 47.2 are located in segment 035-7000 (from Grassy Creek to Horse Fork). The monitoring station at mile 52.3 is located in segment 035-8000 (from Horse Fork to Interstate 81). The monitoring station at mile 61.0 is located in segment 035-9000 (from Interstate 81 to the headwaters).

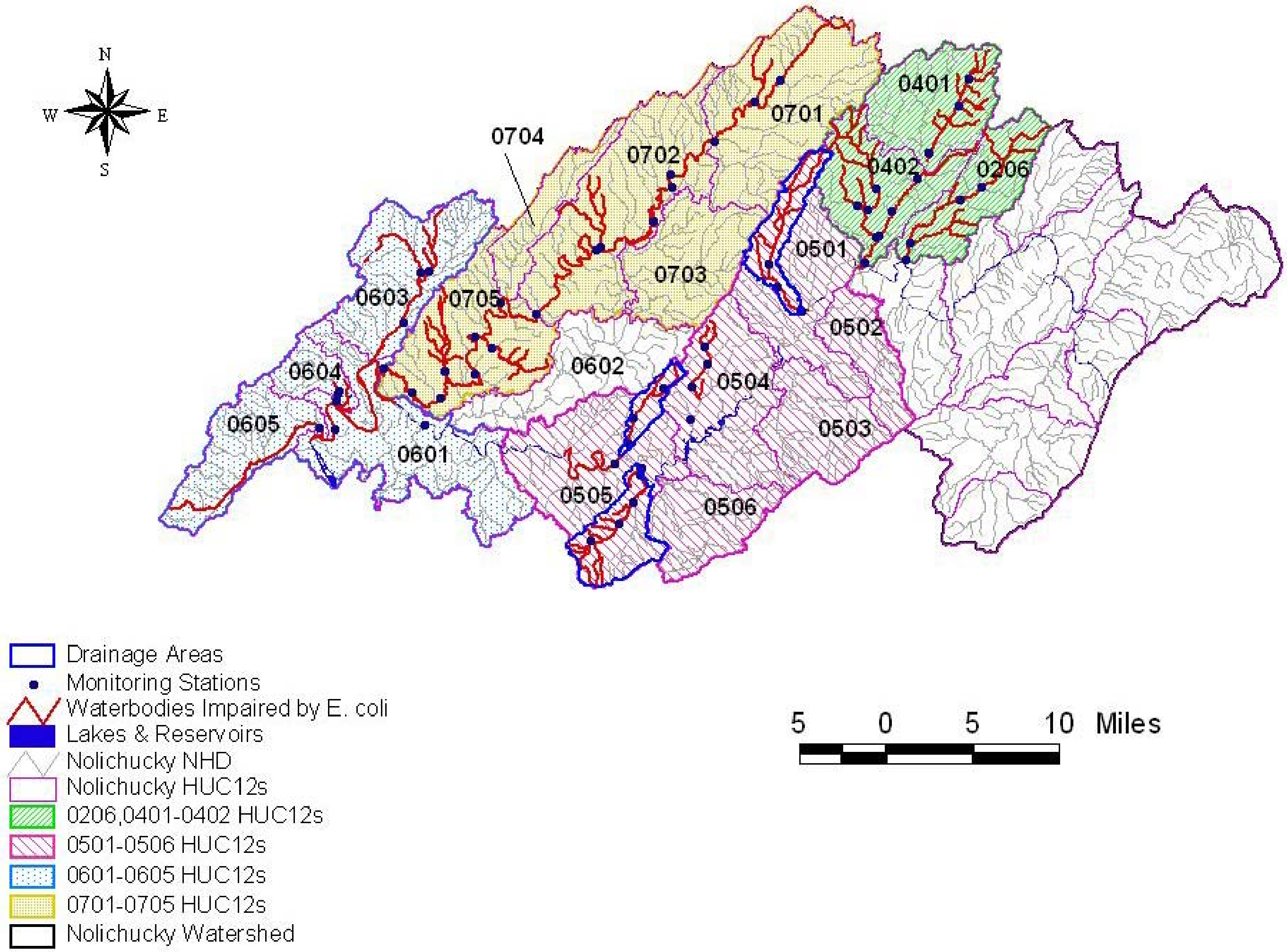

Figure 5. Overview of Water Quality Monitoring Stations in the Nolichucky River Watershed

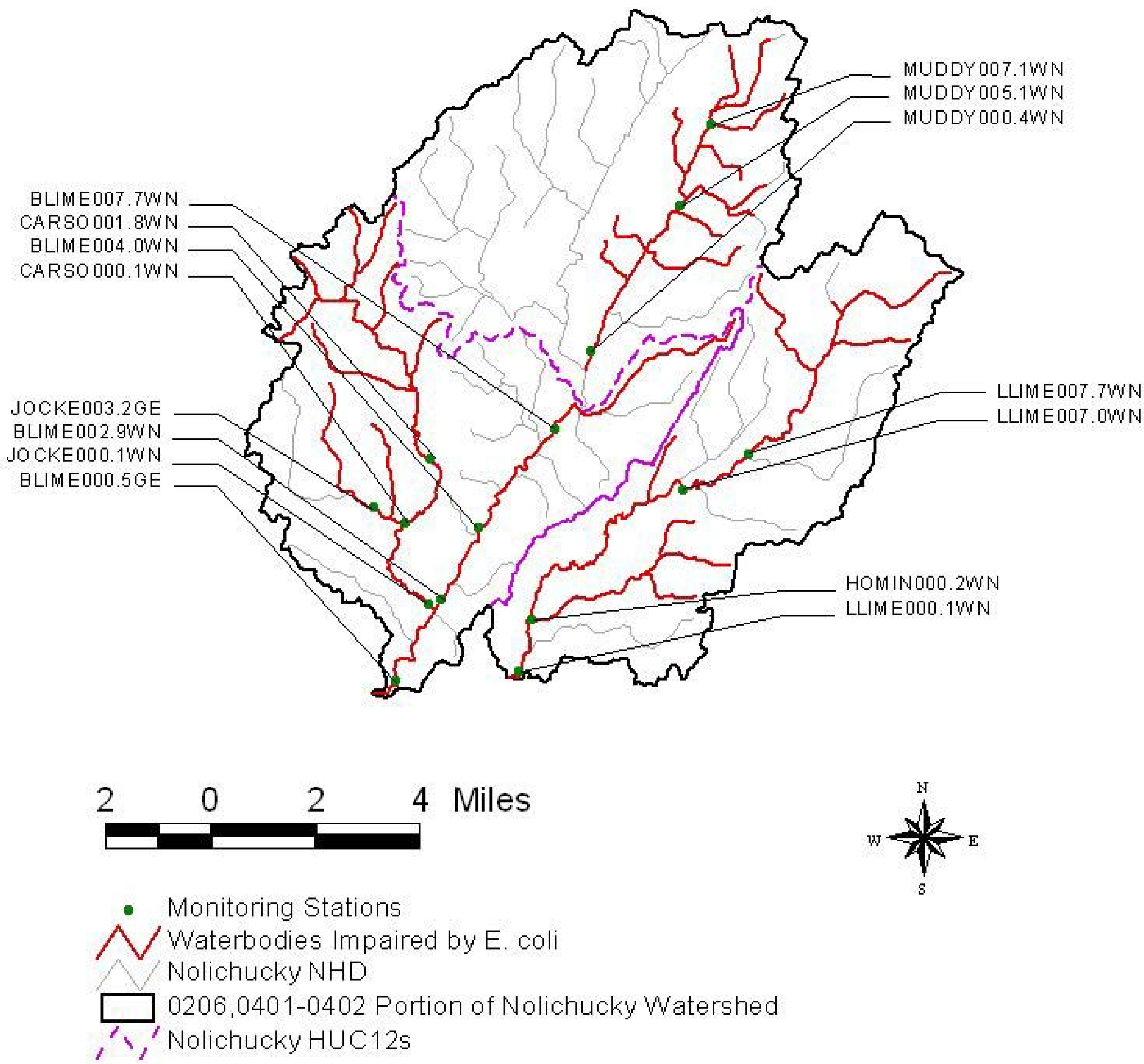

Figure 6. Water Quality Monitoring Stations in the Big and Little Limestone Creek Subwatersheds (HUC12s 0206, 0401, 0402)

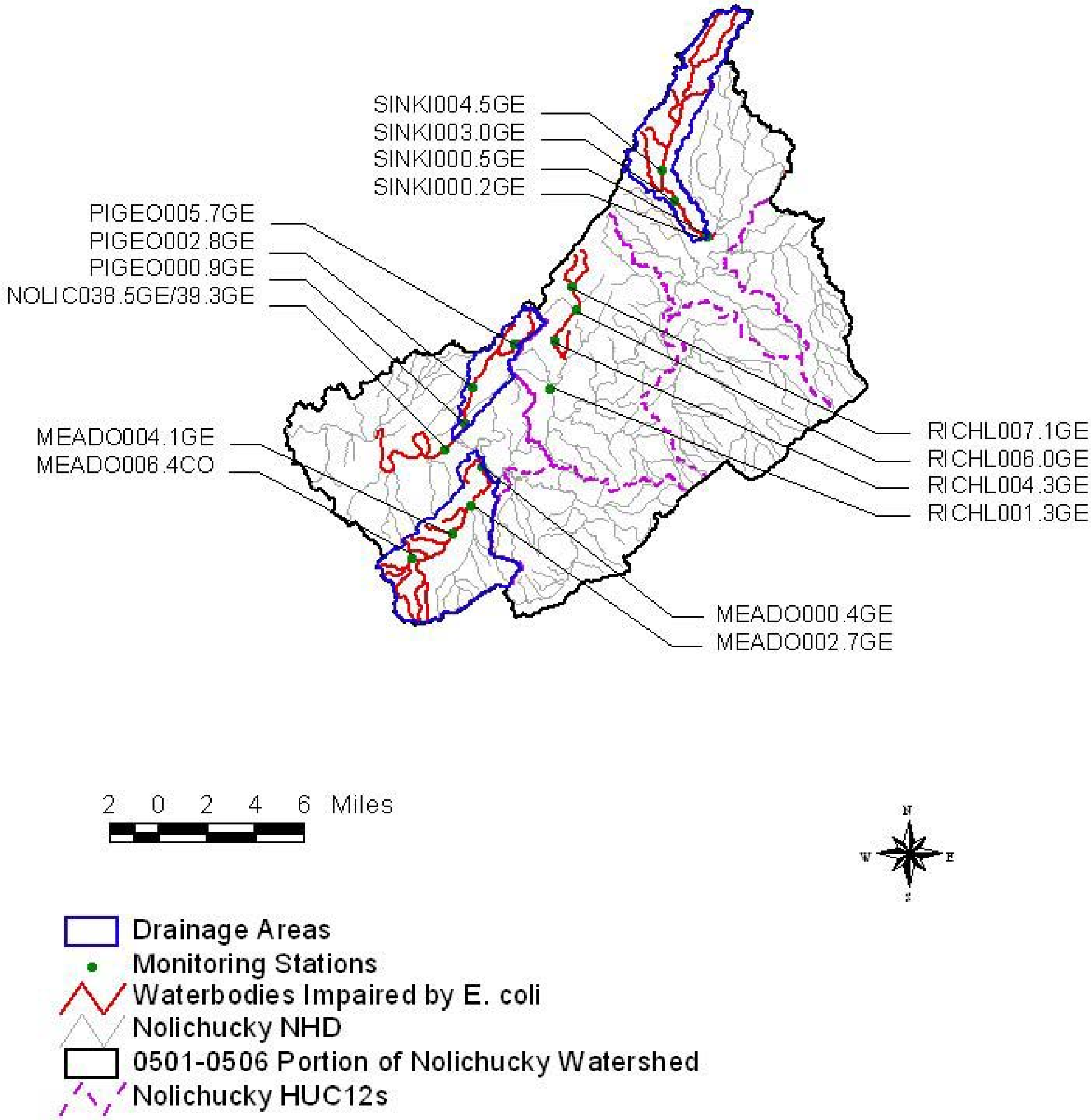

Figure 7. Water Quality Monitoring Stations in the Sinking, Meadow, Pigeon, and Richland Creek Subwatersheds (HUC12s 0501 - 506)

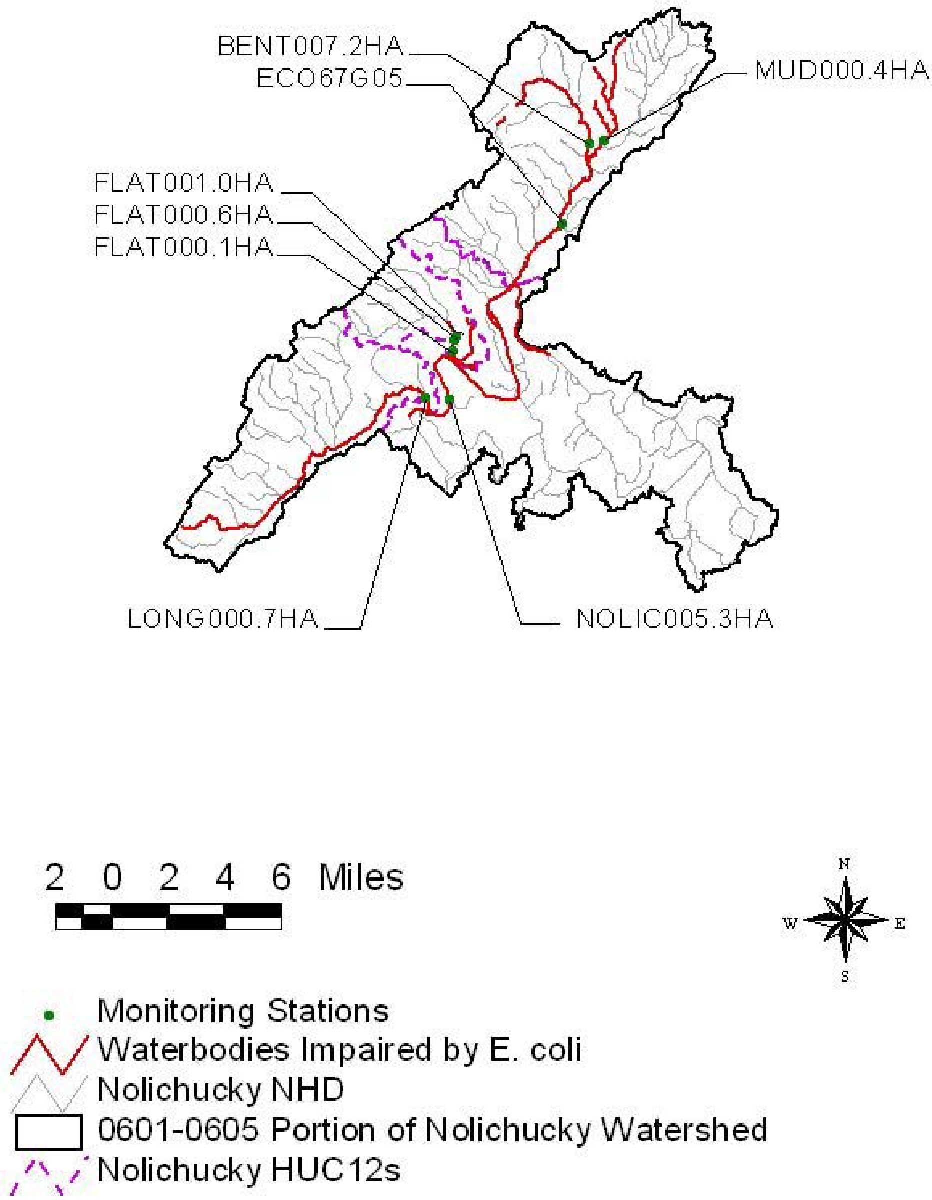

Figure 8. Water Quality Monitoring Stations in the Bent, Flat, and Long Creek Subwatersheds (HUC12s 0601 - 0605)

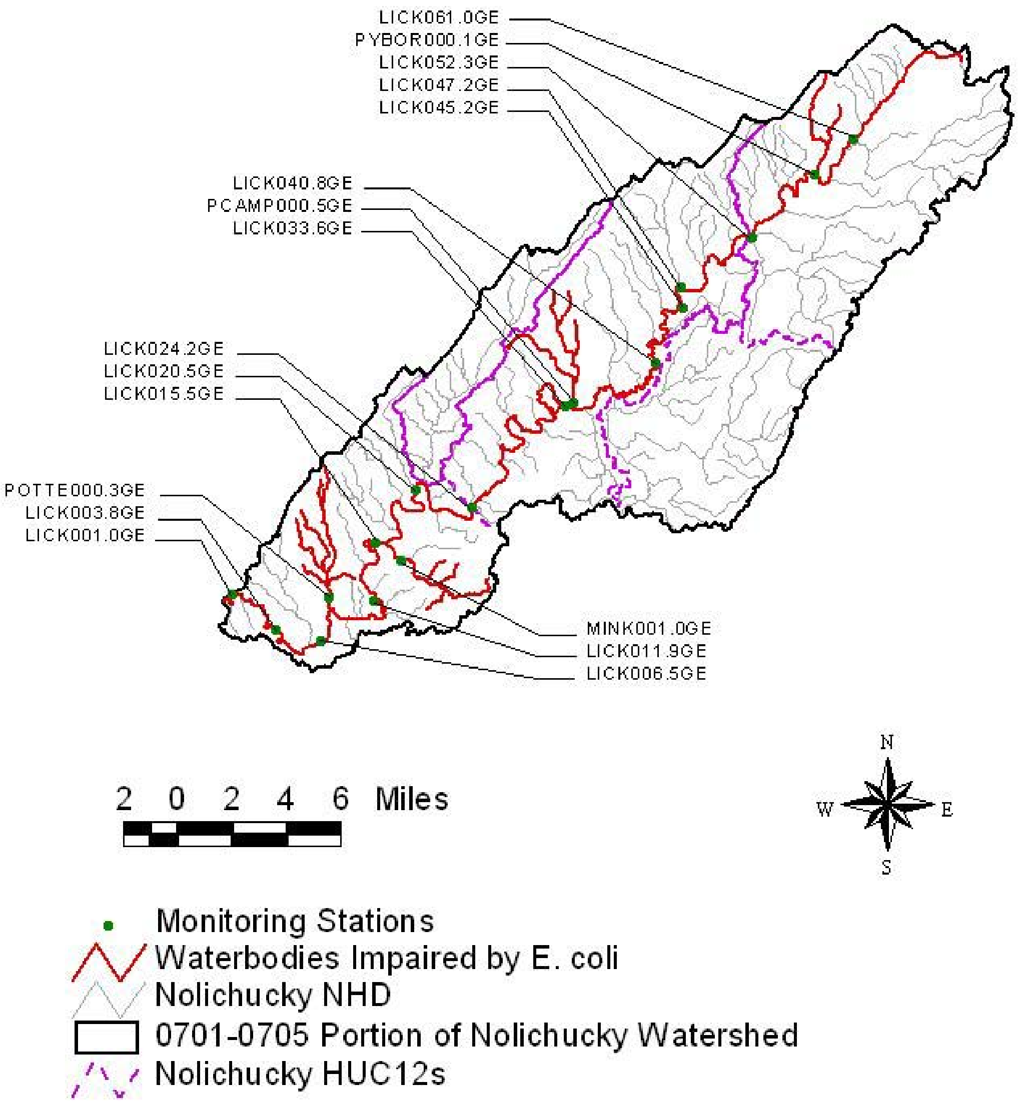

Figure 9. Water Quality Monitoring Stations in the Lick Creek Subwatershed (HUC12s 0701 - 0705)

Table 3 Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
BENT007.2HA	*2001 – 2005*	*23*	*43*	*1,186*	*>2,419*	*13*
BLIME000.5GE	*2000 – 2005*	*27*	*61*	*1,044*	*38,694*	*21*
BLIME002.9WN	*2000 – 2001*	*13*	*127*	*573*	*37,188*	*8*
BLIME004.0WN	2000 – 2005	8	326	901	1,600	3
BLIME007.7WN	2000 – 2001	12	228	1,364	2,419	7
CARSO000.1WN	2000 – 2005	21	816	3,672	13,130	20
CARSO001.8WN	2000 – 2001	12	770	1,895	3,270	10
ECO67G05	1998 – 2005	15	140	419	816	7
FLAT000.6HA	2001 – 2005	23	179	995	2,419	7
HOMIN000.2WN	2005	6	921	1,727	2,500	5
JOCKE000.1WN	2000 – 2005	21	10	1,244	3,990	11
JOCKE003.2GE	2000 – 2001	13	148	1,698	6,630	9
LICK006.5GE	*2000 – 2005*	*7*	*300*	*511*	*1,350*	*2*
LICK011.9GE	*2000 – 2001*	*15*	*71*	*1,202*	*11,300*	*5*
LICK015.5GE	2000 – 2005	7	200	1,409	6,970	2
LICK020.5GE	2000 – 2001	15	88	1,210	6,270	4
LICK024.2GE	2000 – 2005	7	200	549	1,300	1
LICK033.6GE	2000 – 2005	21	20	594	3,310	5
LICK045.2GE	2000 – 2005	7	300	838	2,330	2
LICK047.2GE	2000 – 2001	15	40	928	5,380	4
LICK052.3GE	2000 – 2005	22	32	1,395	16,160	4
LICK061.0GE	2000 – 2005	21	75	1,386	11,530	9
LLIME000.1WN	2005	6	185	868	1,733	2
LLIME007.0WN	2003 – 2005	9	78	1,045	2,419	5
LLIME007.7WN	2005	3	770	38,813	92,080	2
LONG000.7HA	2001 – 2005	11	68	573	>2,419	1

Table 3 (cont'd) Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
MEADO000.4GE	*1999 – 2005*	*18*	*435*	*1,151*	*>2,419*	*17*
MEADO002.7GE	*1999 – 2005*	*17*	*345*	*5,936*	*46,110*	*16*
MEADO004.1GE	*1999 – 2005*	*17*	*313*	*1,169*	*2,690*	*15*
MEADO006.4CO	*1999 – 2005*	*17*	*21*	*1,242*	*5,860*	*11*
MINK001.0GE	2000 – 2005	18	166	2,358	9,330	13
MUD000.4HA	2005	12	7	405	2,419	2
MUDDY000.4WN	2000 – 2005	17	285	1,854	5,650	11
MUDDY005.1WN	2000 – 2001	11	238	2,555	11,300	7
MUDDY007.1WN	2000 – 2001	12	345	3,966	30,760	8
NOLIC005.3HA	*2001 – 2005*	*17*	*1*	*159*	*1,203*	*2*
PCAMP000.5GE	2000 – 2005	4	201	727	1,480	1
PIGEO000.9GE	1999 – 2005	16	121	1,109	4,640	4
PIGEO002.8GE	1999 – 2005	17	365	1,924	3,310	14
PIGEO005.7GE	1999 – 2005	17	101	973	2,419	8
POTTE000.3GE	2000 – 2005	17	10	5,587	45,690	11
PYBOR000.1GE	2000 – 2005	17	12	1,564	7,170	7
RICHL001.3GE	*2000 – 2005*	*25*	*115*	*646*	*2,419*	*12*
RICHL004.3GE	2000 – 2001	15	205	814	2,419	6
RICHL006.0GE	2005	6	866	25,738	129,970	5
RICHL007.1GE	2000 – 2001	15	62	442	1,203	2
SINKI000.2GE	2001 – 2005	6	86	862	1,986	2
SINKI003.0GE	2000 – 2005	18	649	1,811	4,190	13
SINKI004.5GE	2000 – 2001	15	66	799	2,130	5

** Maximum water quality target is 487 CFU/100 mL for Tier II waterbodies and 941 CFU/100 mL for other waterbodies. Tier II waterbodies are italicized.

7.0 SOURCE ASSESSMENT

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that affect pathogen loading and the amount of loading contributed by each of these sources.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); 2) NPDES regulated industrial and municipal storm water discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 16 WWTFs in the Nolichucky River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. Eleven of these facilities are located in impaired subwatersheds or drainage areas (see Table 4 & Figure 10). The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the protection of the recreation use classification.

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems and sanitary sewer overflows (SSOs).

> *Note: As stated in Section 5.0, the current coliform criteria are expressed in terms of E. coli concentration, whereas previous criteria were expressed in terms of fecal coliform and E. coli concentration. Due to differences in permit issuance dates, some permits still have fecal coliform limits instead of E. coli. As permits are reissued, limits for fecal coliform will be replaced by E. coli limits.*

Table 4 NPDES Permitted WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0021229	Denzil Bowman (Greeneville) WWTP	7.0	Nolichucky River at Mile 47.5
TN0021547	Jonesborough STP	0.5	Little Limestone at Mile 12.5
TN0024406	Davy Crockett High School	0.039	Little Limestone at Mile 8.8
TN0040673	Nolichucky Elementary School	0.018	Meadow Creek at Mile 2.9
TN0054844	Plus Mark Inc.*	0.024	Sinking Creek at Mile 2.8
TN0054887	Centerview Elementary School	0.007	Slate Creek
TN0056332	John M. Reed Home, Inc.	0.005	Big Limestone at Mile 3.8
TN0058254	McDonald Elementary School	0.015	War Branch to Lick Creek
TN0058343	Ottway Elementary School	0.009	Lick Creek at Mile 41.1
TN0059366	Lick Creek Valley (Mosheim) WWTP	0.975	Lick Creek at Mile 23.3
TN0063932	Baileyton STP	0.1	Lick Creek at Mile 49.2

* Long term average flow is used for industrial facilities.

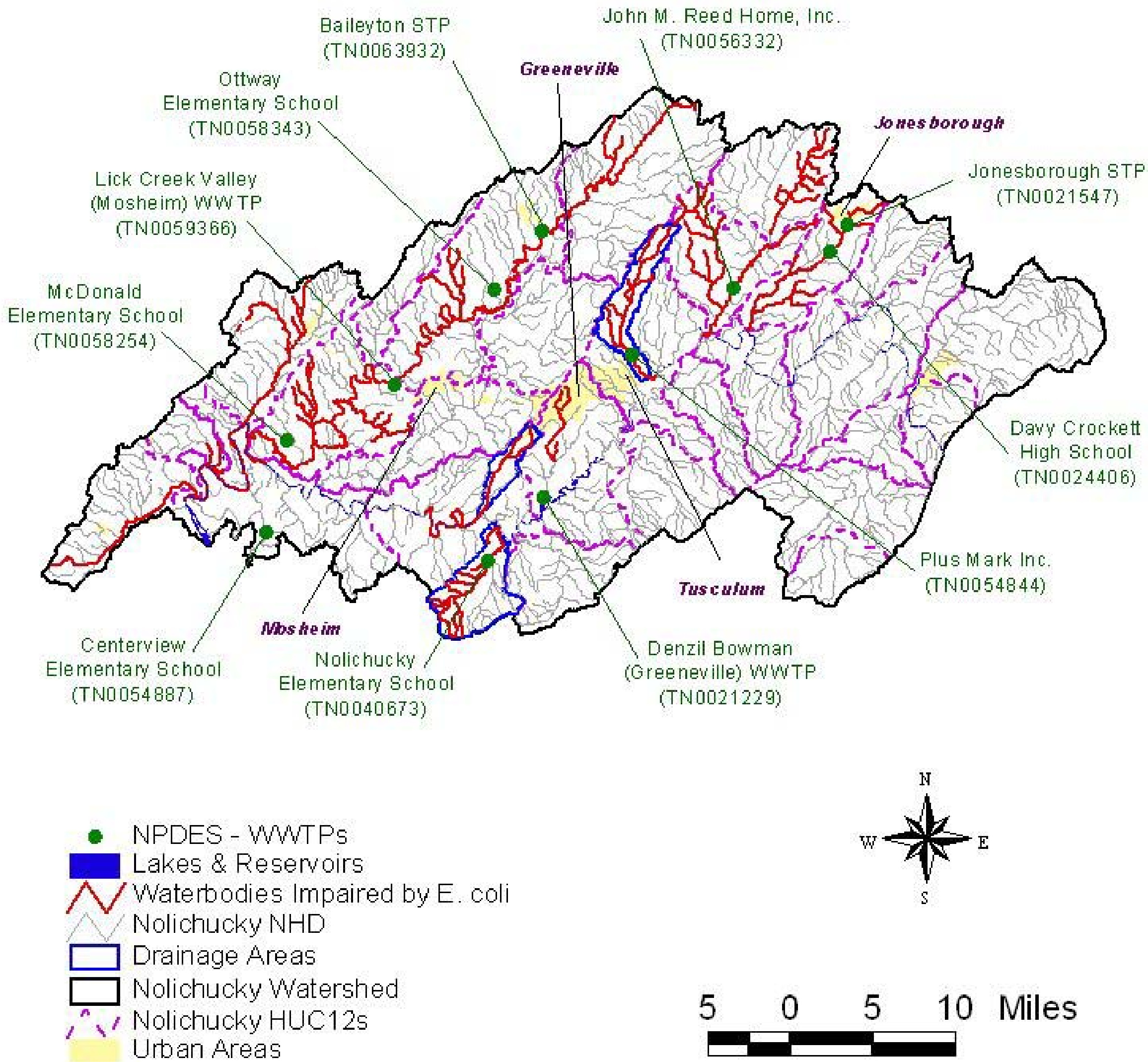

Figure 10. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the Nolichucky River Watershed.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Phase I of the EPA storm water program requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, there are no MS4s of this size in the Nolichucky River Watershed.

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program. A small MS4 is designated as regulated if: a) it is located within the boundaries of a defined urbanized area that has a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile; b) it is located outside of an urbanized area but within a jurisdiction with a population of at least 10,000 people, a population density of 1,000 people per square mile, and has the potential to cause an adverse impact on water quality; or c) it is located outside of an urbanized area but contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. Most regulated small MS4s in Tennessee obtain coverage under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003). Greeneville, Jonesborough, Morristown, Hamblen County, Hawkins County, and Washington County are covered under Phase II of the NPDES Storm Water Program.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit that authorizes discharges of storm water runoff from State roads and interstate highway right-of-ways that TDOT owns or maintains, discharges of storm water runoff from TDOT owned or operated facilities, and certain specified non-storm water discharges. This permit covers all eligible TDOT discharges statewide, including those located outside of urbanized areas.

Information regarding storm water permitting in Tennessee may be obtained from the Tennessee Department of Environment and Conservation (TDEC) website at:

http://www.state.tn.us/environment/wpc/stormh2o/.

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit*, while larger, Class I CAFOs are required to obtain an individual NPDES permit.

As of May 11, 2005, there are seven Class II CAFOs with coverage under the general NPDES permit and three Class I CAFOs with an individual permit located in the Nolichucky River Watershed. There are also one Class I CAFO and one Class II CAFO with applications pending. Nine of these facilities are located in impaired subwatersheds or drainage areas (see Table 5 & Figure 11).

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of E. coli loading are primarily associated with agricultural and urban land uses. The majority of waterbodies identified on the Final 2006 303(d) list as impaired due to E. coli are attributed to nonpoint agricultural or urban sources.

Table 5 NPDES Permitted CAFOs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Permittee	HUC-12 Subwatershed (06010108__) or Drainage Area
TN0078344*	Ray Farms, L.P.	0603
TN0078611	Jack D. Renner	0601
TN0078662	McNabb Farm	0601
TNA000009	A & B Poultry	0701
TNA000026	Lloyd E. Davis	0704
TNA000027*	TNT Poultry	0701
TNA000028	Meadowview Valley Poultry	0701
TNA000084	Woodlawn Gelbvieh	0702
TNA000098	Birdwell Enterprise	0505
TNA000108	B & D Farms	0701

* Permit application pending

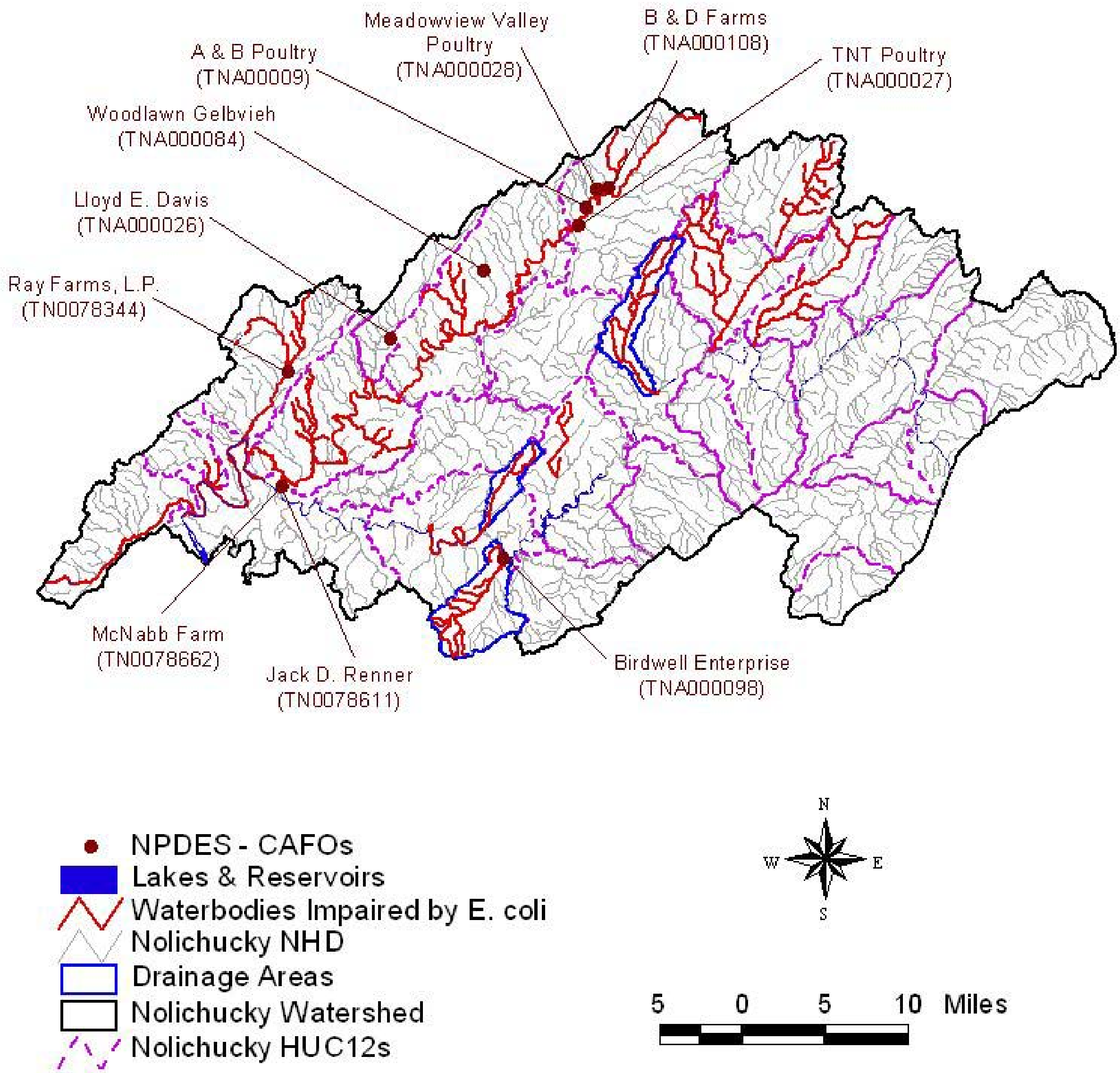

Figure 11. Class I and II CAFOs in and near Impaired Subwatersheds and Drainage Areas of the Nolichucky River Watershed.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile.

7.2.2 Agricultural Animals

Agricultural activities can be a significant source of coliform bacteria loading to surface waters. The activities of greatest concern are typically those associated with livestock operations:

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.
- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).
- Agricultural livestock and other unconfined animals often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture. Livestock data for counties containing E. coli-impaired watersheds are summarized in Table 6.

7.2.3 Failing Septic Systems

Some coliform loading in the Nolichucky River Watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the Nolichucky River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. In middle and eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. Urban land use area in impaired subwatersheds in the Nolichucky River Watershed ranges from 0.2% to 9.9%. Land use for the Nolichucky impaired drainage areas is summarized in Figures 12 through 17 and tabulated in Appendix A.

Table 6 Livestock Distribution in the Nolichucky River Watershed

County	Livestock Population (2002 Census of Agriculture)						
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Horse
			Layers	Broilers			
Cocke	9,442	1,145	289	232,063	121	183	822
Greene	38,445	5,149	2,207	1,119,358	600	717	3,851
Hamblen	9,054	857	430	575,651	956	127	840
Hawkins	20,337	443	1,658	280,310	296	354	2,259
Jefferson	18,634	1,546	1,085	783,172	293	799	2,080
Unicoi	D	0	122	D	36	0	228
Washington	24,068	4,627	557	D	150	1,174	2,929

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2002 Census of Agriculture that would disclose information about the operations of an individual farm or ranch. Any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

Table 7 Population on Septic Systems in the Nolichucky River Watershed

HUC-12 Subwatershed (06010108__) or Drainage Area	Population on Septic Systems
0206 (Little Limestone Creek)	8,797
0401 (Muddy Fork)	11,266
0402 (Big Limestone Creek)	8,297
Sinking Creek DA	1,277
0504 (Richland Creek)	4,202
Meadow Creek DA	1,582
Pigeon Creek DA	528
0601 (Nolichucky R. – mouth)	7,532
0603 (Bent Creek)	11,744
0604 (Flat Creek)	3,718
0605 (Long Creek)	5,930
0701 (Lick Creek – headwaters)	7,756
0702 (Lick Creek – middle)	6,689
0705 (Lick Creek – mouth)	5,222

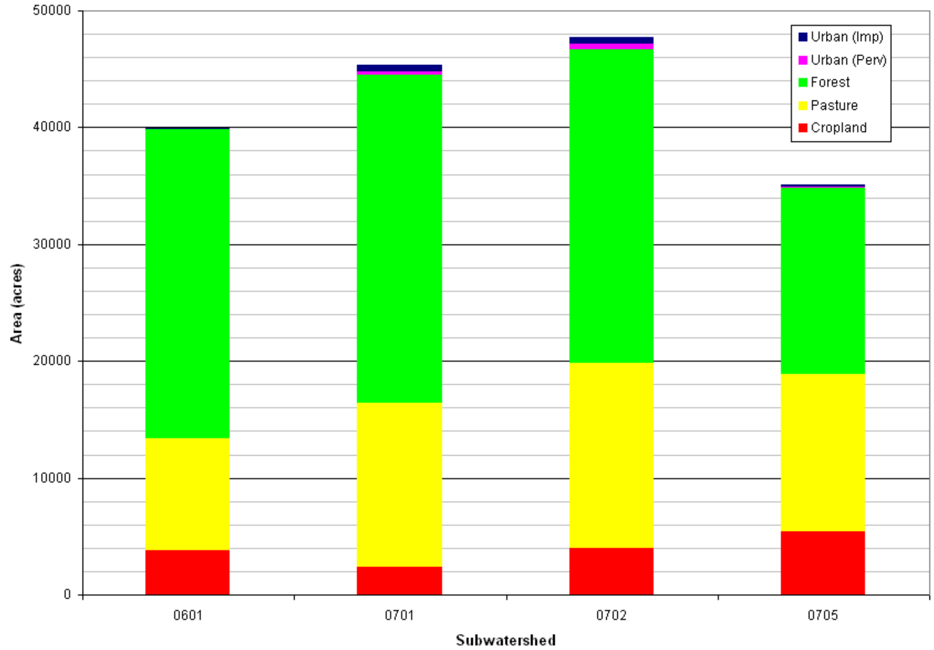

Figure 12. Land Use Area of Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Greater Than 30,000 Acres

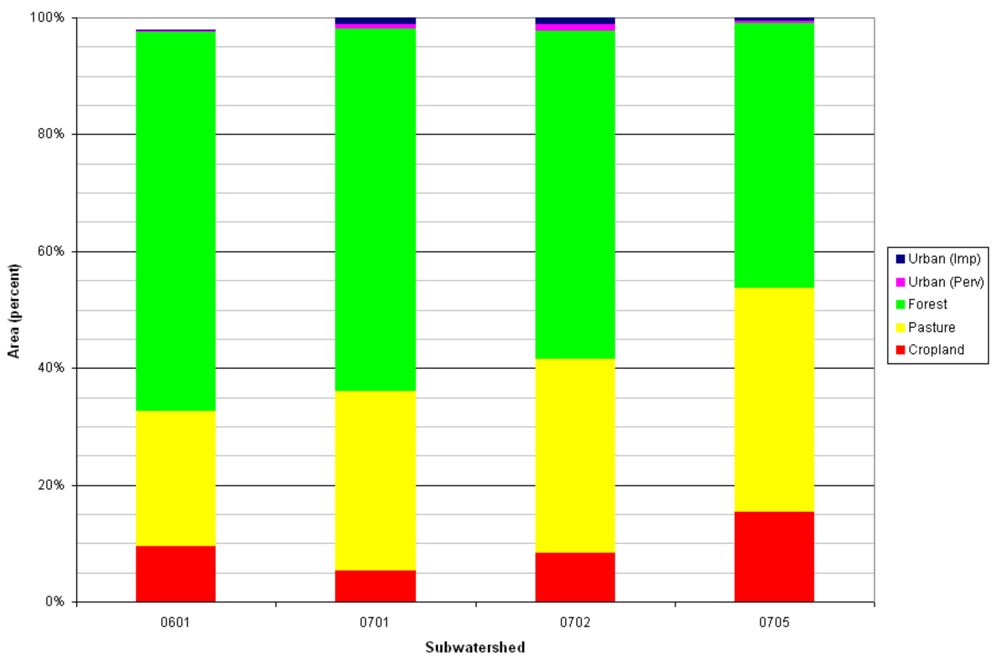

Figure 13. Land Use Percent of the Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Greater Than 30,000 Acres

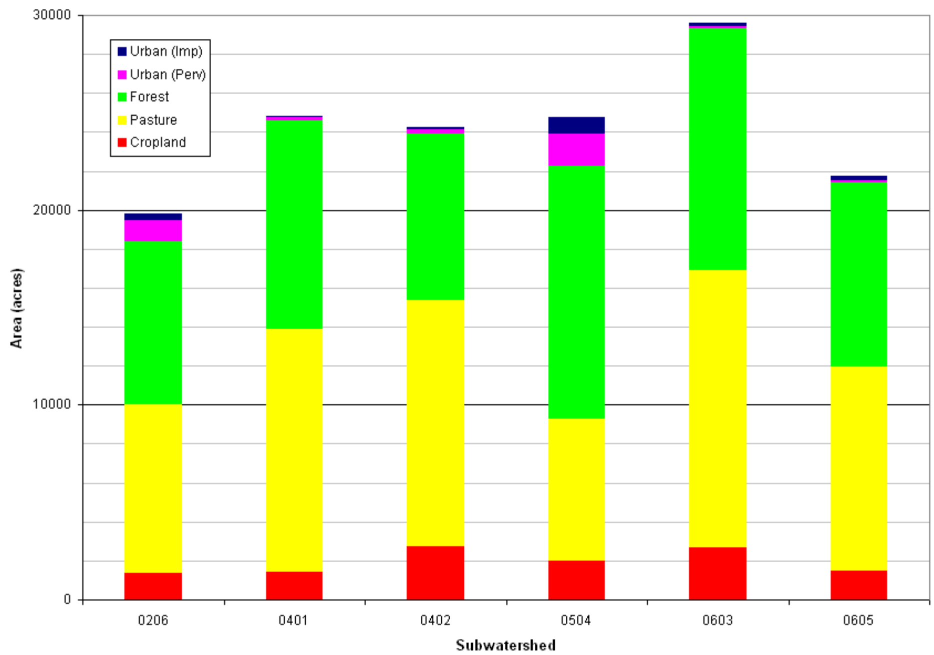

Figure 14. Land Use Area of Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Between 15,000 and 30,000 Acres

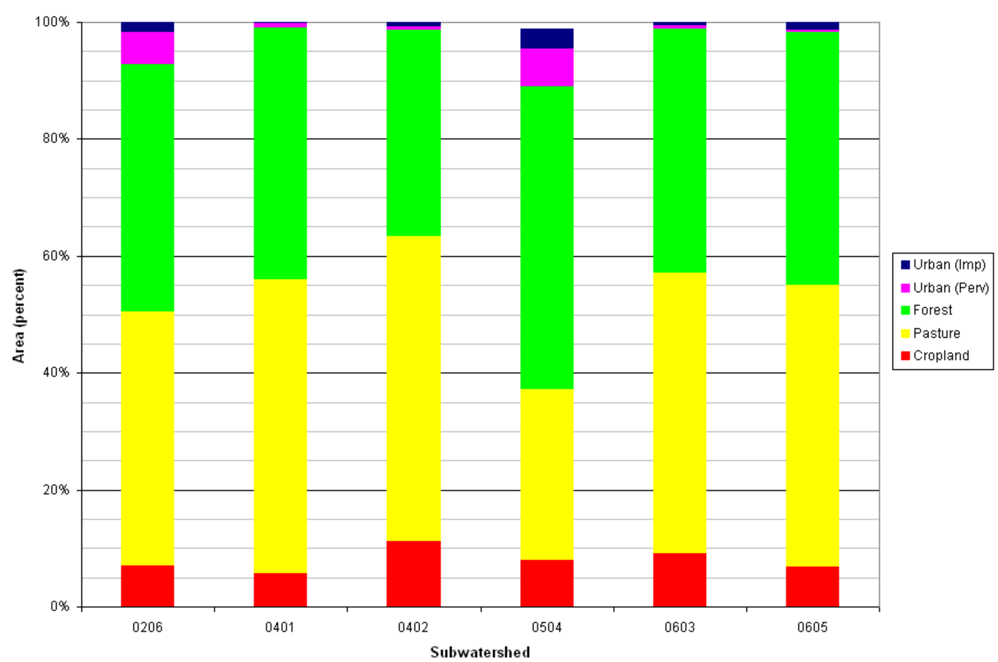

Figure 15. Land Use Percent of the Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Between 15,000 and 30,000 Acres

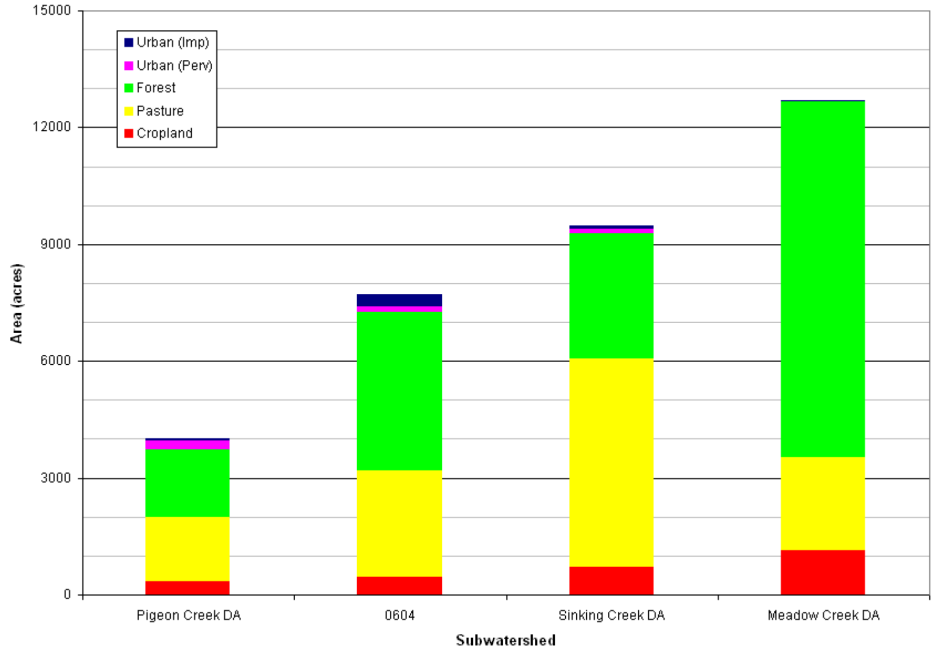

Figure 16. Land Use Area of Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Less Than 15,000 Acres

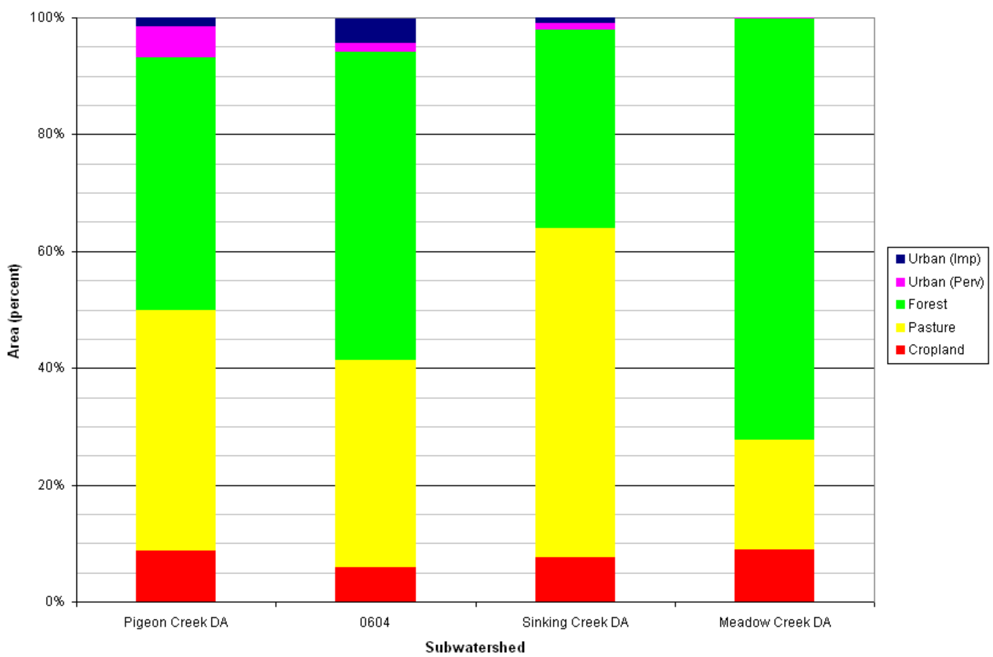

Figure 17. Land Use Percent of the Nolichucky E. coli-Impaired Subwatersheds – Drainage Areas Less Than 15,000 Acres

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

The Total Maximum Daily Load (TMDL) process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

This document describes TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2006 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, TMDLs are expressed as a function of mean daily flow (daily loading function). In order to facilitate implementation, the corresponding percent reduction required to decrease E. coli concentrations to TMDL target levels is also expressed. WLAs & LAs for precipitation-induced loading sources are also expressed as daily loading functions and required percent reductions in E. coli loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs) are expressed as CFU/day.

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the 2006 303(d) List). In some cases, however, TMDLs were developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 8) was based on a careful consideration of a number of relevant factors, including: 1) location of impaired waterbodies in the HUC-12 subwatershed; 2) land use type and distribution; 3) water quality monitoring data; and 4) the assessment status of other waterbodies in the HUC-12 subwatershed.

Table 8 Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (06010108____)	Impaired Waterbody	Area
0206	Little Limestone Creek Hominy Branch	HUC-12
0401	Muddy Fork	HUC-12
0402	Big Limestone Creek Carson Creek Jockey Creek	HUC-12
0501	Sinking Creek	DA
0504	Richland Creek	HUC-12
0505	Nolichucky River Pigeon Creek Meadow Creek	DA
0601	Nolichucky River	HUC-12
0603	Bent Creek Mud Creek	HUC-12
0604	Flat Creek	HUC-12
0605	Long Creek	HUC-12
0701	Lick Creek Pyborn Creek	HUC-12
0702	Lick Creek Puncheon Camp Creek	HUC-12
0705	Lick Creek Potter Creek Mink Creek	HUC-12

Note: HUC-12 = HUC-12 Subwatershed
DA = Waterbody Drainage Area

8.3 TMDL Analysis Methodology

TMDLs for the Nolichucky River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. A load duration curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves are considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and a daily loading function and an overall load reduction were calculated to meet E. coli targets according to the methods described in Appendix C.

8.4 Critical Conditions and Seasonal Variation

The critical condition for non-point source E. coli loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, E. coli bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in the TMDL analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. In all subwatersheds, water quality data have been collected during most flow ranges. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. coli appears to be dominant (see Section 9.3 and Table 9).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were collected during all seasons.

8.5 Margin of Safety

There are two methods for incorporating MOS in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of pathogen TMDLs in the Nolichucky River Watershed, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of WLAs and LAs:

Instantaneous Maximum (Tier II):	MOS = 49 CFU/100 ml
Instantaneous Maximum (non-Tier II):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli daily loading functions and percent load reductions were calculated for impaired segments in the Nolichucky River Watershed using Load Duration Curves to evaluate compliance with the single maximum target concentrations according to the procedure in Appendix C. These TMDL loading functions for impaired segments and subsequent subwatersheds are shown in Table 9. When sufficient data were available, percent load reductions (only) were also calculated to achieve the 30-day geometric mean target loading. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest required load reduction was selected for TMDL implementation. In cases where the geometric mean could not be calculated, it is assumed that achieving the percent load reduction based on the single sample maximum target concentrations should result in attainment of the geometric mean criteria.

8.7 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the allowable loads and subsequent percent load reductions required to achieve instream targets after application of the explicit MOS. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities are generally small in comparison to other loading sources, further reductions were not considered to be warranted. WLAs for CAFOs and LAs for “other direct sources” (non-precipitation induced) are equal to zero. WLAs, & LAs are summarized in Table 9.

Table 9 TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the Nolichucky River Watershed

HUC-12 Subwatershed (06010108__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs				LAs
					WWTFs [a]	Leaking Collection Systems [c]	CAFOs	MS4s [d]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day/acre]	[CFU/day/acre]
0206	Little Limestone Creek	TN06010108510 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	1.920×10^{10}[b]	NA	NA	$2.122 \times 10^{6} * Q - 1.968 \times 10^{6}$	$2.122 \times 10^{6} * Q - 1.968 \times 10^{6}$
	Little Limestone Creek	TN06010108510 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	1.920×10^{10}[b]	0	NA	$1.046 \times 10^{6} * Q - 9.698 \times 10^{5}$	$1.046 \times 10^{6} * Q - 9.698 \times 10^{5}$
	Hominy Branch	TN06010108510 – 0400	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$8.434 \times 10^{6} * Q$	$8.434 \times 10^{6} * Q$
0401	Muddy Fork	TN06010108030 – 0430	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$2.042 \times 10^{6} * Q$	$2.042 \times 10^{6} * Q$
0402	Big Limestone Creek	TN06010108030 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	1.781×10^{8}	NA	NA	$2.246 \times 10^{5} * Q - 3.704 \times 10^{3}$	$2.246 \times 10^{5} * Q - 3.704 \times 10^{3}$
	Big Limestone Creek	TN06010108030 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	1.781×10^{8}	NA	NA	$6.142 \times 10^{5} * Q - 5.285 \times 10^{3}$	$6.142 \times 10^{5} * Q - 5.285 \times 10^{3}$
	Carson Creek	TN06010108030 – 0220	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$3.375 \times 10^{6} * Q$	$3.375 \times 10^{6} * Q$
	Jockey Creek	TN06010108030 – 0200	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$1.859 \times 10^{6} * Q$	$1.859 \times 10^{6} * Q$
0501 (DA)	Sinking Creek	TN06010108064 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	8.548×10^{8}	NA	NA	NA	$2.186 \times 10^{6} * Q - 9.026 \times 10^{4}$
	Sinking Creek	TN06010108064 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	NA	$3.252 \times 10^{6} * Q$
0504	Richland Creek	TN06010108102 – 2000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	NA	0	NA	$1.207 \times 10^{6} * Q$	$1.207 \times 10^{6} * Q$
0505	Nolichucky River	TN06010108005 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	2.773×10^{11}[b]	NA	0	NA	$1.360 \times 10^{4} * Q - 3.493 \times 10^{5}$
	Meadow Creek	TN06010108007 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	3.318×10^{8}	NA	0	NA	$8.513 \times 10^{5} * Q - 2.615x 10^{4}$
	Pigeon Creek	TN06010108033 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	NA	$5.169 \times 10^{6} * Q$
0601	Nolichucky River	TN06010108001 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	2.773×10^{11}[b]	NA	0	$1.007 \times 10^{4} * Q - 2.586 \times 10^{5}$	$1.007 \times 10^{4} * Q - 2.586 \times 10^{5}$
	Nolichucky River	TN06010108001 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	2.773×10^{11}[b]	NA	0	$1.021 \times 10^{4} * Q - 2.621 \times 10^{5}$	$1.021 \times 10^{4} * Q - 2.621 \times 10^{5}$
0603	Bent Creek	TN06010108042 – 1000	$1.20 \times 10^{10} * Q$	$1.20 \times 10^{9} * Q$	NA	NA	0	$3.645 \times 10^{5} * Q$	$3.645 \times 10^{5} * Q$
	Mud Creek	TN06010108042 – 0600	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$9.675 \times 10^{6} * Q$	$9.675 \times 10^{6} * Q$
0604	Flat Creek	TN06010108001 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$3.919 \times 10^{6} * Q$	$3.919 \times 10^{6} * Q$
0605	Long Creek	TN06010108043 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	NA	NA	$9.509 \times 10^{5} * Q$	$9.509 \times 10^{5} * Q$

Table 9 (cont'd) TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the Nolichucky River Watershed

HUC-12 Subwatershed (06010108__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs				LAs
					WWTFs [a]	Leaking Collection Systems	CAFOs	MS4s [c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day/acre]	[CFU/day/acre]
0701	Lick Creek	TN06010108035 – 8000	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	0	NA	6.173×10^{5} * Q
	Lick Creek	TN06010108035 – 9000	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	2.669×10^{6} * Q
	Pyborn Creek	TN06010108035 – 1800	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	7.720×10^{6} * Q
0702	Lick Creek	TN06010108035 – 6000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.882×10^{9}	NA	0	NA	1.920×10^{5} * Q – 3.601×10^{4}
	Lick Creek	TN06010108035 – 7000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.562×10^{9}	0	NA	NA	3.332×10^{5} * Q – 5.733×10^{4}
	Puncheon Camp Creek	TN06010108035 – 0900	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	4.469×10^{6} * Q
0705	Lick Creek	TN06010108035 – 1000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.889×10^{10}	NA	NA	NA	1.251×10^{5} * Q – 2.350×10^{5}
	Lick Creek	TN06010108035 – 2000	1.20×10^{10} * Q	1.20×10^{9} * Q	3.889×10^{10}	NA	NA	NA	6.546×10^{4} * Q – 2.357×10^{5}
	Lick Creek	TN06010108035 – 3000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	NA	NA	NA	1.268×10^{5} * Q – 2.365×10^{5}
	Lick Creek	TN06010108035 – 4000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	NA	NA	NA	1.376×10^{5} * Q – 2.567×10^{5}
	Lick Creek	TN06010108035 – 5000	2.30×10^{10} * Q	2.30×10^{9} * Q	3.861×10^{10}	0	NA	NA	1.385×10^{5} * Q – 2.583×10^{5}
	Mink Creek	TN06010108035 – 2800	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	0	NA	NA	3.400×10^{6} * Q
	Potter Creek	TN06010108035 – 0200	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	NA	NA	NA	4.376×10^{6} * Q

Notes: NA = Not Applicable.
Q = Mean Instream Daily Flow (cfs)

a. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permit; at no time shall concentration be greater than the appropriate E. coli standard (487 CFU/100 mL or 941 CFU/100 mL).

b. The WLA listed is for the subwatershed and is equal to the sum of the WLAs for the individual facilities. WLAs for individual WWTFs correspond to existing E. coli permit limits at facility design flow.

c. Applies to any MS4 discharge loading in the subwatershed.

9.0 IMPLEMENTATION PLAN

The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long-term effort to restore the water quality of impaired waterbodies in the Nolichucky River Watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

All present and future discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permits at all times, including elimination of bypasses and overflows. In Tennessee, permit limits for treated sanitary wastewater require compliance with coliform water quality standards (ref: Section 5.0) prior to discharge. No additional reduction is required. WLAs for WWTFs are derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in new development and re-development
- Pollution prevention/good housekeeping for municipal operations

The permits also contain requirements regarding control of discharges of pollutants of concern into impaired waterbodies, implementation of provisions of approved TMDLs, and descriptions of methods to evaluate whether storm water controls are adequate to meet the requirements of approved TMDLs.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. An effective monitoring program could include:

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.
- Analytical monitoring of pollutants of concern in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time.

The Division of Water Pollution Control Johnson City Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of this TMDL. Details of the monitoring plan and monitoring data should be included in the annual report required by the MS4 permit.

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to CAFOs will be implemented through NPDES Permit No. TNA000000, General NPDES Permit for *Class II Concentrated Animal Feeding Operation* or the facility's individual permit. Among the provisions of the general permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP) that:
  - Includes best management practices (BMPs) and procedures necessary to implement applicable limitations and standards;
  - Ensures adequate storage of manure, litter, and process wastewater including provisions to ensure proper operation and maintenance of the storage facilities.
  - Ensures proper management of mortalities (dead animals);
  - Ensures diversion of clean water, where appropriate, from production areas;
  - Identifies protocols for manure, litter, wastewater and soil testing;
  - Establishes protocols for land application of manure, litter, and wastewater;
  - Identifies required records and record maintenance procedures.

  The NMP must submitted to the State for approval and a copy kept on-site.
- Requirements regarding manure, litter, and wastewater land application BMPs.
- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. The final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

Provisions of individual CAFO permits are similar. NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* is available on the TDEC website at http://www.state.tn.us/environment/wpc/programs/cafo/CAFO_GP_04.pdf

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of pathogen loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

TMDL implementation activities will be accomplished within the framework of Tennessee's Watershed Approach (ref: http://www.state.tn.us/environment/wpc/watershed/). The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance. It relies on participation at the federal, state, local and nongovernmental levels to be successful.

Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. An excellent example of stakeholder involvement and action for the implementation of the nonpoint source load allocations (LAs) specified in an approved TMDL is described in *Guidance for Development of a Total Maximum Daily Load Implementation Plan for Fecal Coliform Reduction* (SCWA, 2004), prepared by the Sinking Creek Watershed Alliance. This document details the cooperative effort of a number of stakeholders and governmental entities to develop an implementation plan for the restoration of water quality in Sinking Creek, near Johnson City, Tennessee. Plan development was funded, in part, through a TDEC 604(b) grant and a Tennessee Department of Agriculture (TDA) Nonpoint source Program 319 grant. The plan is based on land use and pollutant source identification surveys and considers public education & participation, funding resources, in-stream monitoring, best management practices (BMPs), and stakeholder responsibilities. Recommendations for future activities include verification of chemical/biological findings through Bacteria Source Tracking (BST) research, implementation of appropriate BMPs, post implementation monitoring to verify reduction of pollutant loading.

BMPs have been utilized in the Nolichucky River Watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in the Nolichucky River Watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Nolichucky River Watershed are shown in Figure 18. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that BMPs be utilized to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established, maintained, and evaluated (performance in source reduction) over a period of at least two years prior to recommendations for utilization for subsequent implementation. E. coli sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

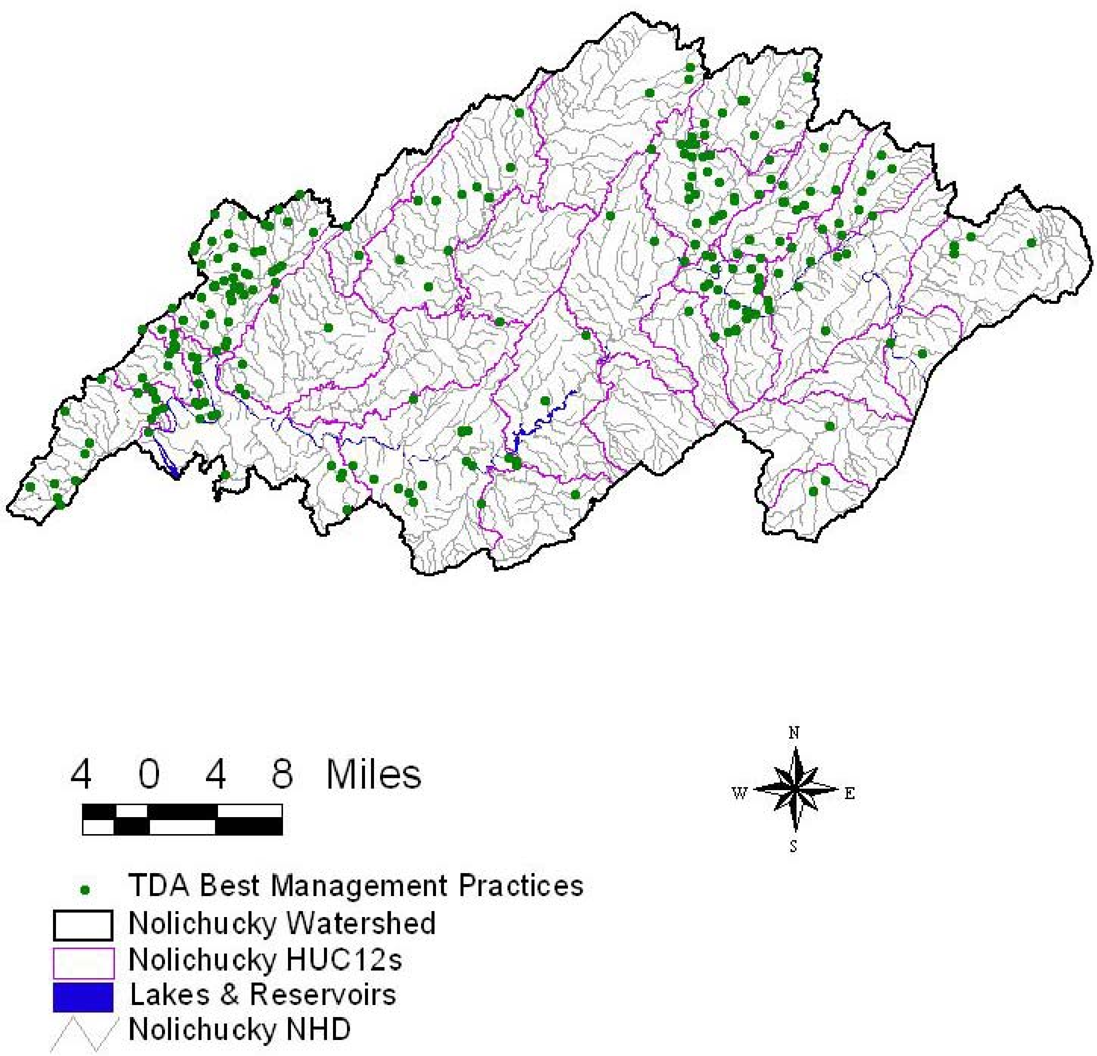

Figure 18. Tennessee Department of Agriculture Best Management Practices located in the Nolichucky River Watershed.

9.3 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and nonpoint problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each E. coli-impaired subwatershed (Figures C-2 through C-24) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration under five flow conditions (low, dry, mid- range, moist, and high). A sample E. coli load duration curve is presented in Figure 19.

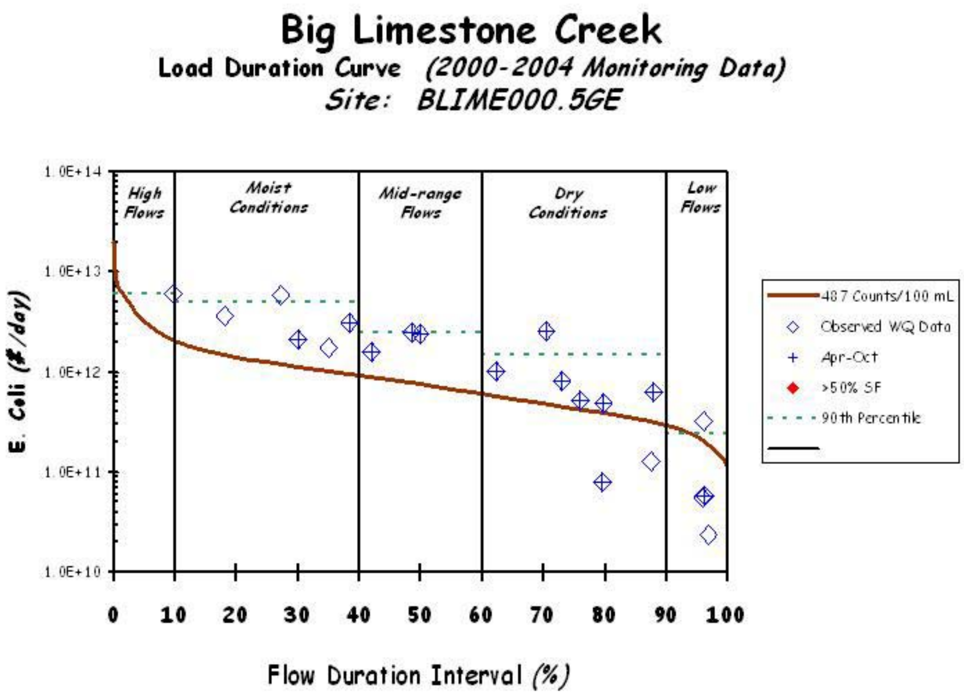

Figure 19. Sample E. Coli Load Duration Curve

Table 10 presents an example of Load Duration analysis statistics for E. coli. Table 11 presents targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, nonpoint sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 11 are a subset of the categories of BMPs and implementation strategies available for application to the E. coli-impaired Nolichucky subwatersheds for reduction of pathogen loading and mitigation of water quality impairment.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the Nolichucky River Watershed.

Table 10 Sample Load Duration Curve Summary (Big Limestone Creek at Mile 0.5)

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Big Limestone Creek at Mile 0.5	% Samples > 487 CFU/100 mL	100.0	100.0	100.0	75.0	25.0
	Reduction	65.6	76.5	68.6	66.9	16.1

Table 11 Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Municipal NPDES		**L**	**M**	**H**	**H**
Stormwater Management		**H**	**H**	**H**	
SSO Mitigation	**H**	**H**	**M**	**L**	
Collection System Repair		**L**	**M**	**H**	**H**
Septic System Repair		**L**	**M**	**H**	**M**
Livestock Exclusion[1]			**M**	**H**	**H**
Pasture Management/Land Application of Manure[1]	**H**	**H**	**M**	**L**	
Riparian Buffers[1]		**H**	**H**	**H**	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

[1] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied may vary.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering the Nolichucky River Watershed is an essential element of the TMDL Implementation Plan. Additional monitoring and assessment activities are recommended to determine whether implementation of TMDLs, WLAs, & LAs in tributaries and upstream reaches will result in achievement of instream water quality targets for E. coli. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. Monitoring activities should also be adequate to assess water quality using the 30-day geometric mean standard.

Tennessee's watershed management approach specifies a five-year cycle for planning and assessment. Each watershed will be examined (or re-examined) on a rotating basis. Generally, in years two and three of the five-year cycle, water quality data are collected in support of water quality assessment (including TMDL development) and planning activities. Therefore, a watershed TMDL is developed one to two years prior to commencement of the next cycle's monitoring period.

Insufficient monitoring data were available for load duration curve analysis of segments 001-2000 and 005-2000 of the Nolichucky River. Additional monitoring is recommended. For all other impaired waterbodies, additional monitoring and assessment activities are recommended only to verify reduction of pollutant loading as a result of implementation of appropriate BMPs within the subwatershed.

9.5 Source Identification

An important aspect of pathogen load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of pathogen impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and pathogens affecting a waterbody. Those methods that use bacteria as target organisms are also known as Bacterial Source Tracking (BST) methods. This technology is recommended for source identification in pathogen impaired waterbodies.

Bacterial Source Tracking is a collective term used for various emerging biochemical, chemical, and molecular methods that have been developed to distinguish sources of human and non-human fecal pollution in environmental samples (Shah, 2004). In general, these methods rely on genotypic (also known as "genetic fingerprinting"), or phenotypic (relating to the physical characteristics of an organism) distinctions between the bacteria of different sources. Three primary genotypic techniques are available for BST: ribotyping, pulsed field gel electrophoresis (PFGE), and polymerase chain reaction (PCR). Phenotypic techniques generally involve an antibiotic resistance analysis (Hyer, 2004).

The USEPA has published a fact sheet that discusses BST methods and presents examples of BST application to TMDL development and implementation (USEPA, 2002b). Various BST projects and descriptions of the application of BST techniques used to guide implementation of effective BMPs to remove or reduce fecal contamination are presented. The fact sheet can be found on the following EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003), the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Baldwin, 2005; Farmer, 2005), and the Sixteenth Tennessee Water Resources Symposium (Layton, 2006).

9.6 Evaluation of TMDL Implementation Effectiveness

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of pathogen loading reduction measures can be evaluated. Additional monitoring data, ground-truthing activities, and bacterial source identification actions are recommended to enable implementation of particular types of BMPs to be directed to specific areas in impaired subwatersheds. This will optimize utilization of resources to achieve maximum reductions in pathogen loading. These TMDLs will be re-evaluated during subsequent watershed cycles and revised as required to assure attainment of applicable water quality standards.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Nolichucky River Watershed will be placed on Public Notice for a 35-day period and comments solicited. Steps that will be taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) Letters were sent to WWTFs located in E. coli-impaired subwatersheds or drainage areas in the Nolichucky River Watershed, permitted to discharge treated effluent containing pathogens, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

    Denzil Bowman (Greeneville) WWTP (TN0021229)
    Jonesborough STP (TN0021547)
    Davy Crockett High School (TN0024406)
    Nolichucky Elementary School (TN0040673)
    Plus Mark Inc. (TN0054844)
    Centerview Elementary School (TN0054887)
    John M. Reed Home, Inc. (TN0056332)
    McDonald Elementary School (TN0058254)
    Ottway Elementary School (TN0058343)
    Lick Creek Valley (Mosheim) WWTP (TN0059366)
    Baileyton STP (TN0063932)

4) A draft copy of the proposed TMDL was sent to those MS4s that are wholly or partially located in E. coli-impaired subwatersheds. A draft copy was sent to the following entities:

City of Greeneville, Tennessee (TNS075710)
City of Jonesborough, Tennessee (TNS075728)
City of Morristown, Tennessee (TNS076031)
Hamblen County, Tennessee (TNS077763)
Hawkins County, Tennessee (TNS075574)
Washington County, Tennessee (TNS075787)
Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to water quality partners in the Nolichucky River Watershed advising them of the proposed pathogen TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following partners:

Middle Nolichucky Watershed Alliance
Upper Nolichucky Watershed Alliance
Keep Greene Beautiful
Appalachian RC&D Council
Smoky Mt. RC&D Council
Tennessee Parks & Greenways Foundation
Natural Resources Conservation Service
Tennessee Valley Authority
United States Forest Service
Tennessee Department of Agriculture
Tennessee Wildlife Resources Agency
North Carolina's Basinwide Planning Program
The Nature Conservancy

11.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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